Climate change adaptation, business model innovation and socio-economic assemblages
A relational analysis of adaptive processes

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Climate change adaptation, business model innovation and socio-economic assemblages: A relational analysis of adaptive processes

by

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Baja California, Mexico from space. Photo by NASA

Earth's climate is unique compared to the climate systems of all known planets, and in our history, we have only experienced a limited range of extreme weather events. We continue to move towards reaching unprecedented concentrations of greenhouse gases in the atmosphere and changes in land and water ecosystems, and eventually our planet will remind us that it can be as violent and inhospitable as its neighbours. Thus, it is time to rethink the purpose and the function of things, institutions, and practices in view of maintaining equilibrium, and choosing rational paths to put our minds and energy.

Abstract

The impacts of climate change will worsen existing problems of insecurity, poverty, inequality and environmental degradation. This multiplier effect requires strategic attention from all social actors. Current climate adaptation research focused on the role of the State and community- and individual-level adaptation, with limited analysis and empirical evidence available on adaptation by the private sector.

This thesis addresses this research gap by analysing how medium and large firms respond to interruptions to business routines caused by climate-related impacts by studying the firm and different actors as economic assemblages where resources, innovation and relationships shape adaptation. The different forms of adaptive actions are forcing these assemblages of the firms themselves and their associates (including workers and host communities) to reconfigure their social and economic functions in distinct adaptation trajectories with different emergent properties. Informed by development theory, economic geography and emerging studies in climate adaptation, this thesis proposes a framework to understand individual firms' adaptive measures framing their adaptive behaviour in relational processes.

Climate change adaptation has a temporal dimension, one that requires to understand the past as a given location, to understand the sources of risk and vulnerability have accumulated through historical processes associated with a variety of social and economic factors, such as land tenure rights, uses of technology, governance processes, poverty and knowledge. It also has a temporal dimension that looks into the future, which requires foresight, flexibility and action to build capacities to cope with the impacts of extreme climate events and rapidly changing climate patterns of climate change.

A characterisation of adaptive actions provided insights into some of these processes in early adopter firms business structures and mechanisms, which evidenced how firms mobilised resources, expertise, information and local innovation in response to climate stress, suggesting different implications of social well-being along supply chains. The thesis argues that established business configurations are failing to undertake adaptation without creating social trade-offs in these local assemblages, due to a failure to normalise socially oriented adaptive actions into their business model.

There is currently an opportunity being missed to take advantage of the social nature of adaptation process to renegotiate more egalitarian relationships between firms and their associates and stakeholders that enhance social well-being and preserve developmental gains. Such negotiations will depend upon recognition of the interdependence between the multitude of actors experiencing climate stress to develop the capabilities necessary for equitable adaptation processes and outcomes under a changing planet. The technical and development approached to leverage the private sector capabilities to contribute to sustainable development, remain largely driven by models and practices that appeal to economic and capitalist views of social life. As climate change presses on social systems, new thresholds begin to be visualised, which present unique challenges for society.

The thesis presents technical responses to climate stimuli which seek incremental adjustments to maintain present functions, but in doing so, these practices reveal the limit to adaptation and potential for forced transformation, where power and resources determine adaptation trajectories. A more just and desirable form of transformation is then considered, one based on a common language and co-production of new ideas and practices, which through cooperation and communication can allow for collective adaptation trajectories, beyond technocratic solutions to "the problem of climate change", but as new spaces to challenge ideas of the private and public.

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Introduction

The signatory countries of the climate change agreement adopted at the 2015 Convention of the Parties (COP21) in Paris established the goal of limiting the rise in the planet's average temperature to below 2 degrees Celsius (United Nations Framework Convention on Climate Change, 2015). Even if this goal is achieved some impacts of climate change will be inevitable, and will require individuals, organisations and communities at all levels to adapt to the changing climate patterns. The Intergovernmental Panel on Climate Change (IPCC) highlighted in the special report (SREX 2012) that effective national adaptation systems rely on a broad range of actors playing differential but complementary roles in climate change adaptation according to their accepted functions and capacities. These include the private sector for-profit firms, whose accepted social functions has been to drive economic growth, innovate and maximise profit for their shareholders. The environmental, social, economic and political challenges presented by climate change requires a renegotiation of the social functions of the private sector if any equitable adaptation processes are desired, and were the opportunities presented by climate change are open to all actors and the costs of climate impacts are shared proportionally across diverse socio-economic scales.

Climate change adaptation research has mostly focused on the role of the State, with limited analysis and empirical evidence available on the adaptation responses and contributions of the private sector. This thesis addresses this research gap by examining the responses of small, medium and large firms to incremental climate impacts and analysing the relationships between firms and different stakeholders in host communities, and the uses of resources, exchanges of information and innovations at the local level in response to current or anticipated climate impacts. The thesis conceptualises individual firms as assemblages, expressed in their business model, which allows to examine the links between the firm's structure, firm-level adaptive actions and the adaptive capacities of local stakeholders within the firm's sphere of influence.

Informed by concepts from development theory, economic geography and emerging studies in climate adaptation the conceptual framework allowed for the characterisation and study of adaptive responses from the perspective of social and economic assemblages, where the available resources and information can influence different dimensions of adaptive capacity and adaptation processes. The precise characterisation of various adaptive actions of early adopter firms are connected to and shaped by the configuration of business activities, which suggests why and where firms deploy adaptation resources, engage expertise, and exchange, control or codify information, and determine the types of barriers to recognising and adopting local innovations necessary for adaptation. The thesis makes contribution to knowledge of adaptation by answering three research questions:

- What are the types of emerging climate adaptation actions amongst private sector firms?
- How can individual firms open or limit adaptation options for host communities?
- What are the sources of business model innovation in the context of adaptation?
- How assemblages change under climate stress? And what new properties emerge in new assemblages?

The thesis presents empirical evidence on the relationship between climate impacts beginning with a grain of barley in the farm field under climate-related stress and the financial planning routines of a firm which suggests how climate related changes can shape a firm's business configuration. This idea drove the research design used to identify climate impacts on business routines and how these influenced or triggered organisational responses to climate stimuli. These different responses are forms of adaptive action.

The findings indicate that current business models driving individual firm's adaptive actions are not equipped to identify value in certain forms of adaptation actions, however, they deploy resources in response to climate stimuli that can shape adaptation trajectories of individuals and groups through resource supply chains. Individual firms channel or constrains flows of resources and information based on economic calculations and business-model-driven profit maximising behaviour. This posits to reinforce mechanisms that lead to unequal distribution of the impacts of climate change and contribute to creating sources of vulnerability.

There are, however, indications of activities driven by local co-production of innovations to improve operations affected by climate impacts, cooperative field learning activities, experimentation with new technologies and informal flows of information between firms that introduce new information and knowledge into the firm's routines, which can provide adaptation options for the firm and some stakeholders. While these can face internal barriers to integration, can also become triggers to leverage the firm's capabilities and modify practices that result in facilitatation of adaptation planning in host communities.

The responses of individual firms in their function of economic agents can assemble or contest different forms of knowledge formation, flows of resources and information central to developing adaptive capacities, for example by enhancing the ability of individuals or households to make decisions adaptation decisions, develop foresight capabilities, dedicate financial resources for adaptation or build social capital.

This power alone, requires to be examined and questioned to allow a negotiation based on rational responses to a new reality often riddled with uncertainty under climate change.

The adaptation actions of individual firms, like deploying experts to improve field operations, deciding on the use of different technologies, shifting their investment practices and priorities or reconfiguring their supply chain to manage climate risk, can either enhance or limit adaptation options for their local associates and stakeholders, such as employees, households, small suppliers, cooperatives and even competitors in their host communities.

The thesis argues that established business configurations fail to recognise social forms of adaptation without creating trade-offs for a variety of individuals, groups and smaller firms in their areas of operation. The basis of capitalism and economic growth demands a business model that maximises profits, but new signs of increasing social demands will require firms to seek ways to allocate resources that might reduce shareholder profits in the short run to contribute to social adaptation processes necessary to cope with changing climate patterns and extreme weather events.

Individual firms must build their adaptation capabilities understanding their choices as social in nature, as adaptation at the core, requires recognising existing development failures and inequality to properly address climate risk. This can open spaces for more egalitarian forms of adaptation. The construct of the firm is the expression of capitalism, as capital accumulation and investment is utilised to expand economic activities, thereby looking at the technical construct of these economic agents through the lens of adaptation, there is an opportunity to challenge the construct of the firm itself, and rethink the mechanism that drives corporate behaviour, values and practices of individual firms.

The thesis further argues, that local co-production and experimentation become entry points to shift the internal mechanisms of firms that determine corporate action, allowing adaptation processes to become a renegotiation of the relationship between the private sector firms and their host communities in ways that enhance the well-being and protect developmental gains. Such negotiations rely on the recognition of interdependence by firms and associates, and a common desire to contribute to the enhancement of adaptation capabilities critical for equitable processes and outcomes.

This PhD contributes to the body of knowledge of adaptation studies by providing a theoretical grounding and advancing the concept of the business model under climate change, combining key concepts from economic geography to examine firms as assemblages in the context of climate change adaptation. Incremental changes then provide insights into the direction or pathway where firms could pursue change, and in locations of extreme climate events and increasing climate pressure on business, increments towards transformation suggests current adjustments are not sufficient forms of change, but rather highlight the need for accelerated shifts and social innovations to overcome outdated functions rooted in historical and capitalist conceptions of economic activity.

The thesis addresses transformation within the organisational scale and outwards among a discrete group of individuals and actors connected in a socio-economic assemblage. While some evidence of potential transformative adaptive actions are presented, the conclusions emphasize the barriers to transformation which firms themselves established by acting according to profit seeking business models, and the potential for forced transformation as some of the elements for reaching short term thresholds in these types of assemblages can be observed in the way economic relationships are established, the forms innovations are used and diffused, the type of information that is exchanges and the decisions on the allocation of investments and value are made by the firm, all which influence the pathways towards socially just transformative change in response to climate change impacts.

While this PhD does not prove causality between the deployment of specific adaptation measures and their effects on different actors, it maps the entry points for socially informed forms of innovation in the private sector, characterises the connection between private sector resources and host communities in the context of adaptation and provides a critique of the basis of economic activity in the face of changing planetary climate.

CHAPTER I

Climate change adaptation, adaptive capacity and transformation

Introduction

Scientific evidence confirms that warming of the climate system is unequivocal. The high concentrations of Greenhouse Gases (GHG) are anthropogenic drivers in the atmosphere that are extremely likely to be the cause of climate change (IPCC 2014). In the next decades, climate variations and increased frequency of extreme weather events will add pressure on natural, social and economic systems (Winn et al. 2010, Holling, 2001, Banerjee 2003, Gunther 2009, King 1995, Lash and Wellington 2007, Linnenluecke et al. 2008, Purser et al. 1995).

While climate change is a global challenge (IPCC 2012; UNEP 2014), its consequences are expected to have a greater impact in the global south, where livelihoods and economies rely heavily on natural resources. These regions are exposed and vulnerable to climate pattern variations, and increased impacts from natural hazards (Rodima-Taylor et al. 2012; Nath and Behera 2010; Mertz et al. 2009;

WBR 2009; Borrell et al. 2008; Mani et. al. 2008; Mendelsohn and Sanghi 2008; Seo and Mendelsohn 2008a, b; Hubler et al. 2008; Karim and Mimura 2008; Paavola and Adger 2005; Klooster and Masera 2000).

In developing regions, the observable impacts of climate change on vulnerable communities include losses from recurring extreme weather events, decreased agricultural productivity, increased food and water insecurity, negative health effects and eroding levels of material resources to cope with the changing climate (UNGC 2012). These impacts build on and exacerbate existing development failures already faced in these regions (Pelling and Schipper 2006; Watson and Ackermann 2000: p. 24). That climate change can threaten development progress has been well-established in disaster studies (Pelling 2005; Pelling 2005 citing UNDP, 2002; Gómez-Echeverri 2000; O'Riordan 2000) and climate change adaptation literature (Ayers and Dodman 2010; Klein et al. 2007; Burton and Van Aalst 2004).

Climate impacts can affect household-level food insecurity in poor communities (Lobell et al. 2008) by threatening local livelihoods (Paavola, 2008; Badjeck et al. 2010) and increasing risks to human health (Patz at al. 2005; Haines, A. et al 2006; McMichael, A. et al 2006). The erosion or loss of resources, security and health leads to higher levels of vulnerability among individuals and households. Vulnerability is increasingly shaped by a wide range of factors, including anthropogenic climate change, natural climate variability, and socioeconomic development (IPCC 2012).

Throughout history, societies have deployed social and individual responses to changing climatic conditions (Behringer 2013; Nyong et al. 2007; Agrawal 1999). Adaptation of human systems to changing environmental conditions is not a new occurrence (Adger 2003). However, the current velocity of environmental degradation and change and its concatenation with development drivers such as exponential population growth, rapid urbanisation, social and economic inequality and a globalised economy will likely make climate change the most significant challenge of the new century (UNGC 2012; Adger 2003).

The IPCC defines climate change adaptation as an "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2014: p. 1758). Adaptation to emerging risks such as increased intensity and recurrence of natural hazards, droughts, heat stress, rising sea levels along coast lines, loss of biodiversity and depletion of fresh water resources will cost developing countries an amount within the range of "USD 75 to 100 billion a year between 2010 and 2050" (WB 2010: p. 64). Adaptation can be understood as different degrees of change, that can be conceptualised as incremental and transformational. The following sections will expand on both notions of adaptation.

Since the signature of the different climate accords and funds, beginning in Copenhagen in 2009 and, the Kyoto protocol in 1992, the signatory countries of the United Nations Framework Convention on Climate Change have begun to allocate financial resources for adaptation "*without any clear idea of how the investments should be used to achieve optimal adaptation*" (Tompkins et al. 2010: p. 628). This is critical to address when allocating public funding to develop capacity among private sector actors. While knowledge, resources and capacity to carry out adaptation actions might be present, actors might not necessarily undertake adaptation (Tompkins et al. 2010). Given this context, it should be considered how funding could be allocated in ways that influence firms' adaptation efforts, and help to positively shape those of their associates.

The Friedman doctrine has largely influenced the for-profit private sector by proposing that firms' only social function is to accrue profit and redistribute value for its shareholders (Friedman, 1970; Friedman, 1988). Over the last century of industrialisation, firms have aggressively expanded economic activities in the pursuit of profit and only recently have some begun to recognise their social and ecological impact and responsibilities in the Anthropocene (Castree 2015). While different authors (Mulligan 1986; May 1998) have critiqued rational choice theory that proposed people are motivated and act on the search for profit, selfish behaviour and perfect knowledge, the evolving landscape under climate change challenges these assumptions even more deeply. Perfect knowledge is now inevitably compromised with climate change bringing unpredictability, prompting us to think beyond technical solutions to the problem of climate change and revealing a new domain where human activity recognises its embeddedness in nature (Hulme, 2014).

Our planet's climate system is highly likely to cross a threshold in the next century where climate impacts no longer can be surmounted without extreme changes in the functioning of social life. In this future scenario, individuals and organisations, will be forced to reconceptualise the breadth of risk, loss and cooperation necessary for wellbeing and performance of desired social functions. These modifications must be undertaken by the diverse social, economic and political actors and will be imperative for them to find a common development vision (Handmer and Dovers 1996). However, climate change is not a social problem seeking a solution, climate change will not be solved by science, politics or economics (Hulme 2014: p.329), but it's the idea around which we can challenge notions of purpose and the ways social life is organized.

A common vision can begin to be informed by science and shared values, were actors with different drivers can overcome the current operational paradigms in the private sector of unlimited growth and perceptions that environmental, economic and social conditions will be controlled with technology and innovation and were social actors view or accept the impacts of climate change as routine or transient events.

1.1 Background

Climate change has been referred to as a threat multiplier (Brown et al. 2007). This multiplier effect also has the potential to be an accelerator of existing socio-ecological challenges, including poverty, inequality, environmental degradation, and development (UN Global Compact 2011: p.15). The IPCC states with high confidence that the impacts of climate change pose severe threats to future sustainable development (IPCC 2014). Facing these challenges requires strategic action from all social actors.

The IPCC (2012) special report on extreme events and disasters highlighted that "effective national adaptation systems rely on different types of actors playing differential but complementary roles in disaster adaptation and risk management per their accepted functions and capacities" (IPCC 2012: p.345; UNISDR 2008a; Schipper 2009; Miller et al. 2010). This recognises that it will not be possible for any single sector or actor to provide all the necessary investments and services to tackle long-term climate adaptation; it will require cooperation, new organisational strategies and the renegotiation of social functions (McLaughlin 2011; Wittneben 2012). As part of this process, the accepted functions of organisations – including small, medium and large firms – are presented with an opportunity to renegotiate their social roles to better correspond with emerging climatic needs and social realities.

However, to date, most climate adaptation research and policy has focused on the role of the State, communities and individuals, with limited analysis and empirical evidence on private sector adaptation actions (Agrawala et al. 2012). In disaster risk policy, more recently, the Sendai Framework for Disaster Risk Reduction recognised there is the "lack of regulation and incentives for private investment into disaster risk reduction" (Sendai, 2015: p. 9). The Sendai Framework states that it is necessary to "articulate roles and collaborations among many stakeholders to assure partnerships and complementarity in activities," (*ibid*: p. 12) particularly for "building knowledge on disaster risk reduction in the private sector" *(ibid*: p. 14) and ensuring that local knowledge informs firms strategies to develop local disaster risk management initiatives that contribute to climate change adaptation processes.

The private sector is made up of individual firms operating under models of the accumulation of capital as their primary function. To survive, a firm must develop a set of competencies and capabilities to sustain profitability and continuous operations. For example, regarding social context, a firm's relationships must be maintained with other firms, clients, suppliers, regulators and labour (Peck and Theodore 2007). In the past decades, the private sector has engaged with the climate change agenda primarily through the integration of mitigation objectives into their operations (Bulkeley 2005; Mikler and Harrison 2011; North 2015) by aligning these measures to corporate benefits and internal drivers that create value and lower costs for the organisation (Bensal 2000).

Climate change mitigation requires technical changes to operations, organisational and technological innovation to reduce CO_2 emissions. These technical changes are leveraged through core functions or drivers of the private sector, they provide cost reduction options, widen the space for integration of new technologies that can increase efficiency and provide a competitive advantage to those firms adopting mitigation strategies in the form of renewed social licence and alignment to the green or sustainable development agendas. The transition into clean production or mitigation activities is a transition to technological and economic innovation, characteristic in the private sector.

However, adaptation requires organisations to face challenges beyond their current capabilities to identify and undertake change (Head, 2010) that requires understanding complex social and environmental variables, a process linked to external issues of vulnerability, poverty and inequality. The ideas of considering these complex variables and dimensions, is a realm considered as social responsibility and moral actions of the firms, where internal business drivers have been considered separately from these social processes and calculations, therefore linking vulnerability and risk in specific geographic locations and times to business operations requires a shift beyond the current scope of corporate behaviour or desired investments.

The challenge for firms to understand or integrate adaptation planning emerge from the complex assemblage of the different social and economic elements of adaptation and the velocity of change of biophysical variables not commonly considered in established business practices. While climate related impacts on business operations for firms connected to vulnerable sectors or regions, such as agriculture, fisheries or tourism, might recognise adaptation needs in the form of business losses or increases in pricing strategies, the responses will emerge from maintaining market competitiveness and be driven by business risk management planning.

The firm relationships also pose a challenge in adaptation efforts, primarily because of the preference to search for economic growth, maximisation of utility, individual shareholder gain and innovation to attain comparative business advantages. These priorities need to be considered alongside the difficulties created by assumptions of the social role, beliefs, values, loyalties and interests of firms. These drivers determine their ability to gain profits and behaviour that has contributed to anthropogenic climate change, social vulnerability and other environmental problems in the first place (O'Brien, 2012). Individual firms will begin to recognise the need to undertake adaptive actions due to constant or substantial disruptions to supply chains, higher production costs or limited resource availability (Busch 2011).

The adoption or integration of adaptation objectives, therefore, present significant challenges for firms because adaptation as a social process challenges the very function and operation of these organisations under increasingly unpredictable climate extremes. An ethos of unlimited growth, resources, and attainment of value is being challenged by a shifting climate that requires adjustments of corporate behaviour far beyond the established horizons of self-interest or preservation, toward action that considers a variety of social actors and environmental changes that might not have been necessary in the past.

1.2 Climate change adaptation

The IPCC (2014) defines climate change adaptation as:

"*The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects*".

And according to the degree of change, there are two forms of adaptation:

- Incremental adaptation: Adaptation actions where the central aim is to maintain the essence and integrity of a system or process at a given scale.
- Transformational adaptation: Adaptation that changes the fundamental attributes of a system in response to climate and its effects.

A combination of stressors, such as those related to climate change, social and economic drivers have led to adaptation across various scales of human systems (Adger 2005) manifested in financial, technological, behavioural and institutional systems (Smit et al. 2000; Berkhout et al. 2004). The various uses of the term led researchers to ask, "Adapt to what? Who or what adapts? Moreover, how does adaptation occur?" (Smit et al. 2000: p. 224). These questions are both conceptual and policy relevant, as the answers focus analysis on different scales, actors or processes. More importantly, they demand an inquiry into dominant actors in adaptation processes, and closer examination of the trade-offs and tensions arising among various individuals, groups or organisations linked by formal or informal relationships facing common climate adaptation needs (Pelling 2010).

Adaptation is a social process where multiple actors at different scales, from the individual level to State level, undertake deliberate change (Pelling and Navarrete 2011) and act in strategic, deliberate ways in response to current and expected climate impacts. Adaptation can be thought of as a process, a set of actions or desired outcomes for a given system (Ayers and Dodman 2010). This includes ecosystems, households, communities, groups, sectors, regions, or countries, where the unit or component of the system can cope with, manage or adjust to the changing conditions, stresses, hazards, risks or opportunities associated with climate change (Smit and Wandel 2006).

A variety of analytical approaches inform different conceptualisations of adaptation. Wise at al. (2014) summarised these perspectives into groups drawing on academic and policy literature. The following Table 1, describes each approach and highlights its key elements.

Table 1 Analytical Framings of Adaptation. Source: Wise et al. (2014).

Framing	Emphasis
Livelihoods-based	This approach emphasises the importance of existing social conditions, individual perceptions, local experiences and informal institutions as critical aspects for determining how communities cope with current climate conditions as a starting point for developing appropriate adaptation responses
Impact-analytical	This approach of the IPCC views adaptation as a single (or few) decision(s) that is (are) taken based on projected future impacts, where it is assumed impacts and decisions can be singled out and formally quantified and evaluated using multi-criteria, cost-effectiveness or cost-benefit analyses.
Institution-analytical	This framing emphasises the need for horizontal integration of policy to mainstream climate change adaptation considerations into existing processes.
Decision making under uncertainty	In this framing, the analysis starts with a concrete decision (e.g., raise dykes) based upon all information on the range of possible impacts, rather than with climate scenarios and projections of impacts.

Social & institutional process	This framing emphasises how in linked social-ecological systems the outcomes of actions can usually not be predicted as they depend on the measures of many agents as well as the social, cultural and natural context. The focal points of analyses thus are institutions (formal and informal rules) that shape the interplay between the actors.
Multi-level governance	This framing emphasises how the cross-scale and systemic nature of climate impacts requires understanding and creating multi-level institutions and organisations that promote vertical and horizontal integration.
Social learning & adaptive management	In this framing, the complexity and nondeterminism of many resource management situations is recognised, and adaptive processes of improving management goals, policies and practices through learning are adopted to help bridge the science-policy gap.

In each framing of adaptation, individual firms and the private sector as a collective group participate directly in the decisions that influence or shape adaptation actions and outcomes. Individual firms have an active yet underreported role. A proposed extension of these framings to the private sector is proposed in the table X below. A further analysis of these framings is then further explained with empirical evidence in chapter IV.

For example, firms are linked to local livelihoods through employment and supply chains, which are critical to advance regional development and build the community assets required to cope with climate-related losses. In local decision-making and policy formulation, individual firms are also involved as economic actors. This is particularly relevant in regional- and municipal-level policy processes, either through direct consultation on or support for local legislation, or the stewardship of public programs, including disaster and emergency response.

In framings of social learning and adaptive management, individual firms can play a critical role in disseminating information on adaptation and encouraging the use of scientific knowledge to inform strategy and innovation acting as knowledge brokers. Conversely, they can also suppress information critical for adaptation through the use of confidentiality measures, patents and other similar protection mechanisms on proprietary information.

Table 2 Analytical Framings of Adaptation and the Private Sector.

Framing	Linkages to the Private Sector
Livelihoods-based	The local social and economic conditions are shaped by the type of private sector activity and practices of individual firms, the type of conditions created for employees and their households. For example, in agricultural regions, the type of wages, insurance schemes, social benefits and practices of farming firms will influence local livelihoods.
Impact-analytical	The view that a single (or few) decision(s) that is (are) taken based on projected future impacts, is linked to the cost-benefit analysis practices in the private sector, a single and formally quantified calculation of investments and returns, this is the basis of business model practices. In an aggregated manner, these decisions will shape adaptation in regions, where individual firms calculate which actions will be deployed and how benefits will be distributed.
Institution-analytical	This framing provides the basis to understand and identify the best possible ways to create policy incentives and monitoring mechanisms for public investments into the private sector for adaptation services, products and capacity building activities.
Decision making under uncertainty	The decision-making scenario is a critical part of modelling and providing a wider framing of adaptation into private sector decisions, this view can account for the relational perspective of adaptation, the barriers of climate information to and from the private sector and the challenges for widening the contributions of individual firms from private to public forms of adaptation measures.
Social & institutional process	In this framing, economic forms of decision making, and financially motivated actions will influence linked social-

	ecological systems. The analyses of institutions, both formal and informal that inform the interplay between the actors, should account for alignment of economic interests, values and paradigms that define the private sector with other actors.
Multi-level governance	This framing calls for an understanding of multi-level institutions and organisations were private sector often might present a consorted view of support or opposition to decisions and participation for key decisions in adaptation governance mechanisms. The consolidated or fragmented views of the private sector are likely to have an implication for political processes and decision making determining good governance systems or obscuring decision-making processes.
Social learning & adaptive management	The existing resources, experience and tools in the private sector to deal with risk and plan for managing external impacts, can provide important inputs for creating local adaptation options and strengthening adaptive capacity. Understanding the ways in which these can be transferred or applied across organizations or activities will be important to leverage resources for adaptation.

Adaptation can be a deliberate movement of human capacities with the purpose of seising opportunities for innovation in moments of crisis. This conceptualisation is the so-called 'adaptive wave model' (Luthe and Wyss 2015), which applies the adaptive cycle of conservation model proposed by Holling (2001) to pinpoint the threshold where deliberate transformation is triggered after resources are conserved, released and reorganised. This model hints at an expansive quality of adaptation actions where the coordination of collective action, innovation and learning lead to sustainable adaptation (Luthe and Wyss 2015). More recent work in geography has introduced spatial and temporal awareness in recognition of the extended conceptions of agency with a wide-ranging engagement of social and spatial complexity (Gandy 2008: p. 56). Geography literature has called researchers to develop theoretical frameworks that explore adaptation from the relational qualities of ecological, technological, social materiality (Head, 2010) to reveal the relationships between actors, the environment and technology that shape their ability to undertake adaptive actions.

In a geographical perspective, different relationships must be examined to identify practices of power and meaning (O'Brien 2012) that shape processes of change under climate stress, and, more specifically, current framings of adaptation that seek to accommodate change, rather than contesting it (Pelling 2011). The current economic paradigms of capitalism are accepted by public and private actors, in some cases modified through small shifts and contributions through social corporate responsibility, but rarely questioned or challenged in the framing of their objectives and functions in national or local systems.

The private sector firms, have accepted long established operational paradigms, and, in response to climate change, their activities seek to accommodate private sector drivers, preferences and values rather than undoing or reconstructing these to respond to the emerging social and planetary challenges. These paradigms are highly likely to present resistance to the social nature of adaptation processes and the imperative to recognise the embeddedness of firms in nature and social life, as the shift to transformative change would require integration of a wider set of values and practices potentially contravening basic mechanisms of capital accumulation and distribution in for-profit firms. This means, adopting a new paradigm of cooperation, delaying profit maximising practices, investing for long term return, potentially directly investing in public infrastructure or extending labour benefits or training to enhance adaptive capacities in locations of high climate risk. These are adaptation-oriented practices that call for firms to recognise a diverse set of interests understood as public in nature among private sector actors.

Several other perspectives inform the studies of adaptation processes, including a cultural analysis of the climate (Hulme 2008), an emphasis on everyday practices (Slocum 2004) at different scales (Adger et al. 2005; Pelling et al. 2008). A dynamic and relational approach that looks at the temporal elements of scale has been proposed by Head (2010) and Leary et al. (2008) which argue that current practices, processes, systems and infrastructure will become increasingly inappropriate for managing climate impacts. These different factors will need to account for velocity and magnitude of biophysical changes, complex social dimensions and the interconnectedness of various actors in a manner beyond the current framings.

The fundamental shifts and strategies required to reduce risks from historically acceptable, but increasingly less sustainable, levels of climate hazard require changes in the behaviour, trajectory and scale of adaptive responses and actions. Adaptive capacities of individuals, groups and organisations are shaped by the possibility to undertake action and choose desirable adaptation options. The degree of change individual firms can undergo or exert will shape the future adaptation options of associates and communities who depend on these actors and are affected by established (or emergent) business models. The next section of the thesis outlines the different elements and dimensions of adaptive capacity to reveal connections to the activities of firms.

1.3 Adaptive capacity

Adaptive capacity is defined by the IPCC as:

> "*the combination of strengths, attributes and resources available to an individual, community, society or organisation that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities from climate change*" (IPCC, 2012: p. 555).

This definition focuses on different actors sets of capabilities and resources to undertake adaptation actions, there are different definitions of adaptive capacity, that are complementary as some place focus on assets and resources, and others hightlight intangible processes and characteristics that allow different actors to cope with external impacts, while the thesis is focused on the impacts from climate change.

The limits of adaptive capacity will be shaped by the lack of access to economic, ecological, social and human resources, inadequate institutions and poor governance structures (Ayers and Huq 2009; Dodman et al. 2009; Huq et al. 2006; Klein et al. 2007). These are some of the social and economic dimensions of adaptive capacity linked to longer-term development processes. The vulnerability of different actors then is shaped by resource distribution, stocks of capital and access to information (Yohe and Tol 2002). In this view adaptive capacity in this view will depend on addressing distribution of resources and information.

Table 3 Five Characteristics of Adaptive Capacity. Jones et al. (2010).

Adaptive Capacity at the Local Level	
Characteristic	**Features that reflect high adaptive capacity**
Asset base	Availability of key assets to respond to changing circumstances
Institutions and entitlements	Existing and evolving institutional environment that allows fair assets to assets and capital
Knowledge and information	System's ability to collect, analyse and disseminate knowledge and information for adaptation
Innovation	Enabling environment to foster innovation, experimentation and explore niche solutions to seek new opportunities
Flexible forward-looking decision making and governance	System's ability to anticipate, incorporate and respond to changes

Table 3 above describes different processes and the ability of different actors in a system to use resources to build capital stock, invest in adequate infrastructure or diversify coping strategies in locations of high climate risk, based on diverse intangible processes such as innovation, experimentation, informed and inclusive decision making (Pettengell 2010). This means that it's not solely about what a system has, but what it does that enables adaptation (WRI 2009). According to Walker et al. (2004), adaptive capacity is the ability of actors within a system to manage or influence resilience to maintain its function – or exert influence over the stability in the face of external pressures.

Folke et al. (2013) identify seven key aspects of adaptive capacity and action:

- the possibility to nurture ecological diversity,
- the ability to sustain social memory,
- the potential to combine different types of knowledge
- the possibility of learning,
- incentivising experimental knowledge,
- building knowledge of institutions, and
- fostering complementary knowledge systems

These capabilities denote the need to engage or act, and to be able to plan and implement sets of actions that can emerge from experimentation and the recombination of different forms of knowledge, understand the sources of risk and vulnerability, and the possibility to influence institutions. These key aspects further include a temporal component of historical social memory, ability to combine different forms of knowledge that might have been developed or introduced in the system at various moments and fostering these knowledge systems in a sustained manner over time. The nature of adaptation is premised on a changing external environment, thus, an adequate solution for a given moment in time, might not be appropriate at another future time.

A key feature of adaptive capacity, which is the potential for actors to experiment with responses to climate-related risks (Wittneben et al. 2012). Therefore, a significant amount of importance lies in pinpointing who is involved in experimentation and its purposes and outcomes. This feature of participation in experimentation must be considered in the analysis of firm responses and their ability to shape adaptive actions. Incentivising experimental knowledge in adaptation would draw from local knowledge, as created by the interactions between formal and informal institution (Naess 2013).

The interactions between different economic agents such as individual firms will have particularly qualities and characteristics were dominant economic capacities might influence a multiplicity of local stakeholders. The different local actors might have direct links to the firm such as suppliers, employees and their households, research organisations providing complementary resources and services, local governments partnering with the firm, or cooperatives working closely with the firm.

The links between the organisation and the multiplicity of local actors might be shaped by formal agreements, contracts or temporary partnerships to support specific firm initiatives or informal relationships emerging from social ties, social gatherings and communication mechanisms to coordinate among partners or competitor firms. The position a focal firm as a central actor allows an examination of how an individual firm can influence the key aspects and characteristics of adaptive capacity in a local community, either directly through engaged operations or remotely through investment, skills and resources being deployed to achieve desired economic functions.

Several authors point to the importance of documenting the responses that might accommodate adaptation or enhance adaptive capacity in a system undergoing change (Smit and Wandel 2003; Keskitalo 2004; Sutherland et al. 2005; Vasquez-Leon et al. 2003). The adaptive capacity of a firm is determined by its ability to make changes or adjustments necessary to avoid new risks arising from climate change, its ability recover from climate impacts or its capability to seise new opportunities resulting from adaptation options (Berkhout et al. 2004).

While the firm operates under a structure that is driven by maximising profit, and organisational capacity linked to what Cohen and Levinthal (1990) termed “absorptive capacity”: *the ability of the firm to recognise the value of new information and assimilate and apply it for commercial purposes*, not all actors will be driven by the same search for profit or have the similar capabilities to respond to climate impacts.

Thereby, if social forms of adaptation, or adaptation that protects or enhances forms of sustainable development, it will not be not sufficient for the firm to develop the capacity to adjust and respond to climate risks; it must convert this capacity into economic value through the recombination and use of the new information, that might also be shared or distributed through these formal and informal channels to a variety of local actors.

Understanding how? and why? firms might choose to distribute resources and information is critical to explore the link between business models and a firm's ability to enhance or erode key dimensions of adaptive capacity.

Recent empirical work indicated that lack of access to up-to-date climate information, lack of finance, competing priorities, lack of knowledge and short-term perspectives all impede firms' integration of climate adaptation measures in business planning. The firms' limited social relationships to knowledge broker organisations, such as universities, research centres and local government institutions, constrain its adaptive capacity. Furthermore, failure to convert resources into resilience-building activities and to grasp the longer-term strategies that still reside outside firms accepted planning horizons (Kuruppu et al. 2013) diminishes the development of necessary capacities for adaptation.

1.4 Adaptation as actions

Adaptation in human systems can be a "process, action or outcome" (Smith and Wandel 2006: p.282). Biagnini et al. (2014) propose that adaptation actions refer to the tangible actions that can modify institutions, policies, programs, or the environment in response to experienced or predicted climate change impacts. These adaptive actions are best understood when broken into means-end chains (Eisenack and Stecker 2013).

These reveal the functional role of actors involved and expose barriers to adaptation. This approach provides specificity to the examination of the function of firms in a closed production system, where interconnectedness with associates shapes the firm's responses. Interconnectedness exposes firms to secondary climate impacts felt primarily through its associates or partners; for example, as changing levels of farm productivity impact processing businesses.

Adaptive actions can be developed or deployed through social learning (Pelling and High 2005) and innovation (Luthe and Wyss 2015: p. 676) with the potential to trigger transformative adaptation processes. The precise conceptualisation of transformation remains open (Feola 2014) by describing change at clearly identifiable scales in relation to space and time (Mustelin and Handmer; Holdshlag and Ratter 2013), were fundamental shifts in power and values (Pelling 2011) can be realized through a discrete process that fundamentally alters the components of a system, in form, function or state (Park et al. 2012).

In regard to individual firms in the private sector, this might be expressed as a redistribution of power among multiple actors or changed capitalist values determining the internal drivers of the business model or accepting trade-offs between profit maximisation for social value deriving from firm's adaptation actions. Adaptive actions are sector- and location-specific, and might include developing more resource-efficient production techniques, conserving natural resources, sourcing from local businesses to strengthen the economic base or building local capacity throughout a firm's value chain to manage climate risk (UNGC 2011). Firms might not differentiate adaptive actions from routine activities, as this concept might still be elusive for managers (Pauw and Pegels 2013).

The benefits of adaptation actions might be diffused across space and time, and in some cases, might not accrue as direct benefits to the provider of any adaptation resources (Tompkins and Eakin 2011: p. 3). For example, in Scotland, a policy in flood management encourages landowners to enhance flood storage capacity on their land to reduce public expenses in flood disaster management (Howgate and Kenyon 2009). The policy is based on the wiliness of private landowners to cooperate on the basis of trust and shared cultural values, as other studies found that common interest and trust resulted from collaborative dialogues involving data (Connick and Innes 2003: p. 184). The incentive in these cases were driven by dialogue, information and shared cultural values. There are broad forms of adaptive actions described in the literature on adaptation, where early adopters may be more conscious, proactive and strategic in adaptation planning. The non-material types of adaptive actions include information exchanges or training activities for associates, the different beneficiaries of these measures will develop the ability to undertake actions or make decisions with the knowledge attained from these resources. However, the extent of these benefits might not be immediately clear. For example, improving ridge orientation in farmlands or training farmers in wildfire management strategies can develop new capabilities necessary to improve irrigation or disaster risk reduction in the future.

The material types of adaptive actions include deployments of resources that develop the recipients' ability to undertake actions in response to climate or disaster impacts, which might be easily measured or quantified, such as in-kind donations for disaster relief or communication technologies, as these may immediately result in additional assets or capabilities. These types of resources can be targeted to specific locations in response to identified climate impacts or might also be deployed to areas where no measurable immediate benefit can be traced. For example, it might take years for an adaptation initiative like planting shaded tree areas to protect crops from increasing temperatures to achieve the desired goal of lowering heat stress on crops and managing flood risk along agricultural land perimeters.

1.5 Adaptation as transformation

Adaptive capacity becomes strengthened as the result of different types of resources that allow organisations, individuals and households to circumvent climate risk. The mobilisation, combination and accumulation of resources can shift the distribution of risk, power and agency in a productive system. This recombination can open transformative opportunities, where transformation alters fundamental attributes such as values, regulations, financial, technological or biological elements (IPCC 2012).

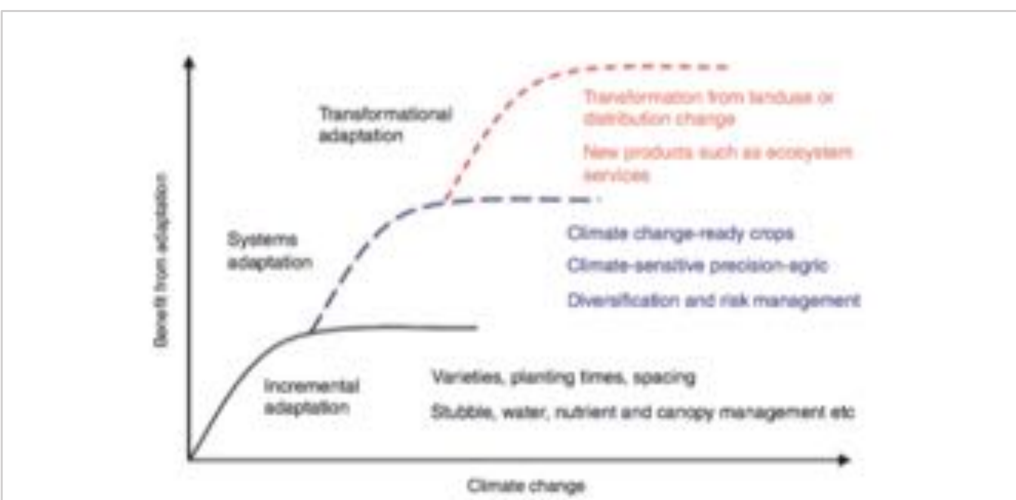
While transformation might originate from deliberate actions, forced transformation might occur from unsustainable conditions in a current system, in the context of climate change, transformation is a complex process operating at personal, cultural, organisational and institutional levels (O'Brien and Sygna 2010) driven by the pursuit of better opportunities or the realisation of the imminent or inevitable limits within existing adaptation paradigms (Dow et al. 2013).

However, these limits, will not solely be measures against climate related impacts, but social, economic and political drivers might accelerate transformative processes. Walker et al. (2004) define transformation as changes in the stability of a given landscape, introducing a new defining factors, for example when a household shifts their livelihoods or changes in economic activities of an entire region. These changes in fact can be driven by deliberate actions from the actors in the system, that might also lead to forced transformation at larger scales in a socio-ecological system (Folke et al. 2010).

These changes can imply trade-offs and conflicts, such as gains for some agents and losses for others within the same system (Harvey and Pilgrim 2012; Sunderland 2011; Baymer-Farris and Bassett 2012). These redistribution and reconfiguration of resources, and functions will impact the adaptive capacity, with some losing their ability to cope with stress or finding eroding capabilities from lost income, resources or sources of livelihoods, and others gaining additional capacities from new opportunities or widening economic or political spaces to influence or determine the outcome of the reconfiguration in the system.

Transformational adaptation is shaped by innovation and changes in the ability of a system to anticipate or respond to climate impacts (Marshall et al. 2012; Park et al. 2012; Kates et al. 2012; O'Brien and Sygna 2010; Nelson et al. 2007). This degree of adaptation may become indispensable as climate change impacts increase in frequency and range (Rickard and Howe 2102). Transformative adaptation can proactively help to "*capture benefits, address pre-existing structural issues, pre-empt possible problems or to accommodate the long lead times on associated decisions and actions*" (Rickards and Howden 2012: p.242). An example from the same authors illustrates transformative adaptation actions in agriculture. The following figure (Figure 1) shows incremental changes towards transformative processes. The figure solely conceptualises changes in the relationship between climate change and the benefits from adaptation, but beyond each leap a multiplicity of social and economic drivers informs the choice to move towards a following stage for change, or a forced shift to the next stage.

Figure 1 Transformative Adaptation in Agriculture. Source: Rickards and Howden (2012).



Incremental adaptation begins at the farm level with changes in crop varieties, shifting of planting and seeding times for new crops or spacing of the plants to improve plant health. Increasing impacts of climate change demand system-wide activities to draw greater benefits from adaptation actions, such as resilient climate crops, technology to manage water resources and diversification strategies to compensate for climate related losses. Finally, transformational adaptation processes are underway when fundamental changes to land use or relocation are needed to maintain functions and wide-ranging ecosystem services to improve environmental management capabilities are introduced.

Transformational approaches to adaptation look beyond managerial adjustments in response to climate impacts to deeper structural changes that modify the social conditions that created vulnerability in the social, economic and cultural spheres in communities in the first place (Pelling 2010). These structural changes open questions about the internal drivers of firms solely pursuing profit and value for shareholders (Freidman 1970).

There is growing evidence that the potential for substantial and rapid changes in future climate might make the transformational change necessary in human systems (Rikards and Howden 2012: 241), including in adaptation efforts (O'Brien 2011; Pelling 2011; WGBU 2011; Cork et al. 2010). In some primary industries, firms may need to undergo a transformation, making fundamental changes in function or structure to remain viable under increasingly direct climate change impacts (Marshall, et al. 2012).

Wine growers in Australia, for instance, have purchased land and relocated to cooler regions of the country to maintain their ability to produce wine under increasingly extreme climate conditions (Park et al. 2012). Being able to identify and distinguish a transformational change is dependent on being explicit about scale (Marshall et al. 2011). While a large spatial scale is one possible dimension, transformation can also be thought of differently in relation to smaller scales, ranging from an individual to a family to a community, or from a single farm business or property, to a sector or region and across any one dimension. The level of change that counts as 'transformational' is subjective and relative (Rickards and Howden 2012).

The current operations of firms can be deliberately transformed through changes in routines and practices (O'Neill and Handmer 2012) that open pathways for new information and knowledge to be created or exchanged between the firm and external actors. These pathways shape the configuration of relationships of the firm. They also provide indications of potential transformation. For example, a firm might decide to transform agricultural land to sites for industrial activity or the development of sustainable energy infrastructure to compensate for inevitable losses from climate impacts. This would effectively change the business configuration of the firm by altering sources of value and relationships with external associates.

According to Marshall et al. (2012) transformational capacity is derived from four factors: 1) understanding how risk and uncertainty are managed, 2) skills in planning, learning and organising, 3) the level of financial and psychological flexibility for change and 4) willingness to undertake change. These factors inform the relationship between firms' adaptation behaviour under current operational paradigms – which do not account for adaptation – and its capacity to enhance or undermine the capabilities of associates, stakeholders or community to develop these factors and undertake voluntary transformational changes as necessary or desired.

Conclusions

Adaptation to changing climate patterns is a process that society has undergone in the past, but the complexity of factors shaping vulnerability and adaptation today, and possible long-term consequences for nature and society, are unprecedented. The social, political and economic factors driving changes, and the multiple impacts of climate change will lead to transformational changes at various scales, in some controlled and deliberate changes will allow individual actors, organization and communities to direct changes towards optimal or desired outcomes. However, not all actors or systems will undergo deliberate changes, the same driving forces behind these changes will also force transformation to those unable or unwilling to reconcile the different pressures from both human and environmental pressures.

Maintaining development progress and environmental sustainability while adapting to climate impacts will require cooperation amongst a variety of actors. In the face of increasing climate extremes and impacts, the accepted functions of different economic agents will be challenged by increasing social demands. In this context, most recent research has focused on the role of the State without considering the responses and influence of firms related to adaptation options in locations under climate stress. It is therefore necessary to first understand adaptation actions as building blocks of adaptation responses and examine the capacity of actors to combine, share and use resources to achieve different stages of adaptation.

In the first stages of adaptation, minimum adaptive capacity is necessary, but, as climate impacts increase, transformational capacity might be required to undertake the necessary actions to cope or choose change. This chapter presented several analytical elements to interpret the empirical evidence of individual firm's adaptation actions, and the firm's role in shaping the adaptive capacity of individual production systems through interaction with a variety of local actors, including the firm's stakeholders, but more broadly expanding to those indirectly affected by the firm's decisions.

This analysis will help develop a theoretical basis to interpret the behaviour of firms undergoing climate stress and the responses that can influence adaptation and transformational capacities in host communities. The following chapter unpacks conceptions of the private sector and firms to identify the possible spaces and routines where climate change impacts might prompt adjustments and determine how these changes might influence local adaptive capacities, both within the firm and within associates and stakeholders.

CHAPTER II

Firms, economic geography and assemblages

Introduction

This chapter presents the analytical framework of the thesis. The framework developed is informed by concepts from development studies, economic geography and innovation theory, with the aim of exploring the relationships between firms as economic agents and associates under climate stress. The chapter engages with broader debates on climate change adaptation and economic geography by combining the literature on the role of the private sector in sustainable development with a discussion on relational approaches to the understanding of firms.

The first section introduces the broad concept of the private sector and provides specificity regarding the idea of the firm. It unpacks the internal architecture of firms by presenting the concept of the business model to focus on the elements and properties of the firm and establishes the connections to external associates and stakeholders.

The second section explains the conceptual difference between organisational change and organisational contributions to change in the context of climate adaptation. This distinction assists in interpreting adaptive actions framed in recognised mechanisms of deployment of resources for adaptation in the private sector. It explains the limitations of these mechanisms, advances the notion of the business model as critical to understanding adaptation processes and presents innovation theories to inform the analysis of the changes unfolding within firms.

The final section presents concepts from economic geography and introduces assemblage theory to interpret some of the processes, functions and adaptive actions of firms as economic agents with the potential to shape, shift and transform social configurations and adaptation trajectories in host communities.

2.1 Firms and the private sector

The term "private sector" is used unevenly and interchangeably across academic and policy literature (see Allison, 2012; Davies, 2011). According to the Inter-American Development Bank (IADB), the private sector encompasses all

> "*economic activities that do not involve production by the public sector and includes all for-profit firms regardless of size, activity (goods, services, or financial), or location (urban or rural), and institutions specifically established to serve the private sector such as industry associations*" (IADB 2004: p. 4).

The original proponents of three-sector theory (Fisher et al. 1939) differentiated economic sectors into three levels: primary (agriculture), secondary (manufacturing and processing) and tertiary (service sector). These categories are useful but broad, as the evolution of individual firms and economic activities have made necessary more nuanced descriptions. For example, firms engaged in the commercialisation of agricultural products can both be growers of crops in the primary sector, but also provide financial services to smaller producers to increase market share or invest in the financial services markets to finance primary sector activities extending their operations into the services sector.

A more recent categorisation helps to better define such firms by loosely describing three spheres of activities: the goods sector, in which companies produce tangible items such as commodities, minerals or merchandise; the services sector, in which companies provide intangible products such as accounting, banking or education; and the joint goods and services sector, in which companies provide both goods and services or rely on assets or raw materials to deliver services (Agrawala 2011). More dynamic positioning of firms opens analytical space to overcome the limitations of static definitions of firm functions and behaviour.

The focus of this research is on for-profit firms as social units, with overlapping interests in different economic sectors, where adaptation processes can be observed (Berkhout 2004). These organisations are: "*key actors in the social landscape and contribute to economic growth, job creation, investment, technology transfers, innovation, and delivery of goods and services as well as potential for ecological degradation and social exploitation*" (Di Bella et al. 2013, p. 6).

The Organization of Economic Co-operation and Development (OECD; 2005) defines small and medium-sized enterprises (SMEs) as non-subsidiary, independent firms. There is a considerable body of literature on SMEs, which is discussed in the following section. The most common upper limit designating an SME is 250 employees; small firms are those with fewer than 50 employees while micro-enterprises have at most 10, and big businesses are those with more than 251 employees.

This thesis focuses on medium and large-sized firms and their stakeholders. The firms might maintain family-owned or locally-managed operations, which differ from multinational or public corporations, as these would be characterised by a different relationship to local communities due to corporate structures and governance protocols. Recent development debates on individual firms have differentiated between private sector development where investments and regulatory frameworks are geared towards enabling the creation of new firms, economic expansion and supporting economic growth (see Gibbs 2008; Kindornay and Riley 2013) and private sector contributions to development (see Bryers and Rosengren 2012; Di Bella et al. 2013; Nelson 2013) where actions taken by private actors directly support sustainable development. These terms help to establish a conceptual difference between actions that solely seek economic gains and maximisation of profits to redistribute among shareholders, and actions that move beyond routine business operations to actively pursue innovative business strategies and inclusive business models aimed at maximising profit while contributing to development goals (Lucci 2012; WBCSD 2010).

In practice, however, this differentiation remains obscure and it has not been closely explored in the context of climate adaptation. Depending on the firm, adaptive actions might be observed at different scales, such as the household, community, group, sector, region or country. Such engagements can contribute to building adaptation mechanisms able to cope with, manage or adjust to some of the changing conditions, stresses and hazard risks of climate change, and seek opportunities (Smit and Wandel 2006). The firm is a social institution that changes continuously (Mikle-Horke 2004: p.100), as demonstrated by the emergence of so-called for-benefit corporations recognised in some state legislation in the United States.

These for-benefit organisations integrate values like inclusive governance, transparent reporting, fair compensation, environmental responsibility, community service and contribution to the common interest as primary functions and drivers of their operations. This is a legislative innovation unique to some state legislations in the United States, where the foundational legal structure of the firm has been incorporated and recognized by the state to function according to these principles. In the United Kingdom and the European Union, a similar model might be found in the for-benefit corporations, however, these are not profit seeking firms. The "public benefit" indicates that the organization has obtained a status, and not that it has been incorporated or as a distinct legal entity. The public benefit status is granted after the organization has been incorporated and registered as a legal entity in the form of an association or a foundation (Moore et al. 2008).

The for-benefit organisations in the United States "*must provide in their formative documents that fiduciaries must consider the impact of their decisions on various nonshareholder constituencies, including the environment and the local, state, and national economy*" (Reiser 2011: p. 594). These firms have incorporated social and economic value into their business model and represent a transformational shift in the firm's social functions. The figure 2 below illustrates a spectrum of the different social functions of firms and not-for-profit organisations in the so-called fourth sector.

Figure 2 Firms categorised by purpose. Source: The 4th Sector Report (2012).

The categorisation of organisations according to their purpose allows for the identification of the functions of firms in social and economic life and widens even further the analytical framing of firms' economic objectives. It also helps differentiate how their approaches are informed by factors such as ethics, the pursuit of sustainability and social engagements. The above spectrum reflects a changing landscape of private-sector firms and emerging trends of differentiation in the economic system.

Some examples of the types of contributions of private sector firms to sustainable development dimensions include: health and education objectives, creating inclusive value chains, responsible business practices, incorporating climate sensitivity into business operations, implementing human rights principles in business operations including gender and child human rights frameworks, improving accountability and transparency in business operations, and targeting the transfer of technologies to host communities (Di Bella et al. 2013).

This changing landscape illustrates the potential changes in the private sector allowing to re-examine the social function of firms in relation to other actors in climate change adaptation processes (Pauw and Pegels 2013) emerging from deliberate or forced transformational forms of adaptation. This is particularly relevant to the converging adaptation and development agendas, where development funding is tied to climate change adaptation (Fry 2010).

The social functions of private sector firms can be renegotiated, reconstructed and reoriented toward socially cooperative objectives. This adds a dynamic quality to the static paradigm of profit increases and shareholder value that has solely determined private sector activities in the past century, particularly by the proponents of the so-called Friedman doctrine, which states "*There is one and only one social responsibility of business – to use its resources and engage in activities designed to increase its profits.*"(Friedman 1962: p.112), which is at the core of capitalism.

2.2 The business model

The business model is the internal architecture of the firm, represented by a set of internal relationships that interact to support the firm's desired functions. It has only been a site of study in the last decade, because of interest generated by changes to the business environment, such as the emerging knowledge economy, the growth of the internet, the outsourcing of many business activities and the restructuring of the financial services industry around the world (Teece 2010: p.174). These innovations led to new different business structures and configurations to lower costs and create value by leveraging resources from various sources and locations.

There is no single definition for the business model (Zott et al. 2011: p. 5; Shafer et al. 2005), but some authors agree that the business model is a vehicle for the creation of value (Casadesus-Masanell and Rikard 2010; Teece 2010; Morris 2005). It refers to the set of internal processes by which a firm can create value (production) or capture value (marketing and sales). These processes are susceptible to the impacts of external change, for example in market and regulatory conditions, and increasingly environmental change. Osterwalder (2009) proposed a decomposition of the business model, using a so-called business model canvas. Table 4 below illustrates the organisational components of business models.

Table 4 Business Model Canvas. Source: Osterwalder (2009).

Business Model Canvas		
Component	**Questions**	**Examples/characteristics**
Key partners	Who are key suppliers? Partners? What resources do we acquire?	Optimisation and economy, reduction of risk and uncertainty, capitalise resources
Key activities	Distribution channels? Key activities? Revenue streams?	Production, problem solving, platform and network
Key resources	What resources do we require?	Physical, human, financial, intellectual

Value proposition	What value do we deliver?	Newness, performance, customisation, design, status, price, cost reduction, risk reduction
Customer relationships	What are expectations?	Personal assistance, automated services, communities, co-creation
Channels	Through which channel(s) does the firm reach customers? Which one's work? Most cost efficient?	Awareness, delivery, post sales services
Cost structure	Most important costs? Which resources and activities are most expensive?	Economies of scale, economies of scope, variable costs, fixed costs
Revenue stream	What value do customers pay for? What is the revenue model? Pricing tactics?	Asset sale, usage fee, list price, negotiation, real time markets, volume dependent, customer segment, licencing, advertising, (fixed and dynamic pricing)

The table 3 above presented the components and processes necessary for creating financial value for the firm, but fails to recognise innovation and aspirational factors, which are central to understand adaptive actions and innovations. This is a capital-centric approach with a narrow managerial view of firm functions. The flows of information and resources are organised according to economic drivers to maximise profits, reduce cost and minimum compliance with legislative requirements. This provides an example of the limited view of individual firm roles in contributing to social, economic and environmental life.

Another approach to understanding business models advanced by Morris et al. (2005) breaks down business models into three main dimensions: *economic, operational and strategic*. The search for profit drives the economic dimension and sustaining profit streams (Stewart and Zhao 2000). The operational is represented by the firm's configuration, focusing on internal processes to create value (Morris et al. 2005) including knowledge management, production and service delivery methods along with logistical chains. Finally, the strategic dimension places emphasis on the firm's market position, interactions across organisational boundaries and growth opportunities (Teece 2010; Porter 1979).

The business model concept can also incorporate processes of cooperation, partnership and joint value creation (Magretta 2002; Mäkinen and Seppänen 2007; Mansfield and Fourie 2004). Afuah and Tucci (2001, p. 4) describe the business model as the operational basis for any firm or organisation; it is a system that is made up of components, and the linkages between these elements. These are system-level, firm-centric viewpoints, but their openness to the relational view widens the analytical space (Zott et al. 2011). They help in understanding the firm's internal architecture, but also see external components and relationships as part of the firm. In this view, the business model represents the way that activities and resources can be organised and used to ensure sustainability and growth for the firm (Demil and Lecoq 2010).

The aim of the neoclassical business model is to achieve an advantage over competitor firms through innovation and differentiation. Here the most efficient business models are those sufficiently differentiated from others and hard to replicate (Teece 2010). In this line, Chesborough (2010) proposed that the business model fulfils the functions of articulating value propositions to advance the firm's objectives, identify a market segment for the firm's products and services and organise the revenue generation mechanisms of the firm, defining the structure of the value chain and the position of the firm in its value network.

The dynamic nature of the business model concept opens the possibility to integrate new ideas and normative directives as desired. The business model of for-profit firms can include aspirational characteristics: "the business model is not just a description of how they go on, but depicts how they want to be in the future, a model to strive for an ideal outcome" (Baden-Fuller and Morgan 2010: p.165). These provide new drivers for desirable future results and give important direction towards new forms of organising firm relationships. For non-profit organisations, business models structure and map the mechanisms by which they intend to deliver social rather than economic value (Dahan et al. 2010: p. 329).

A complete business model may include activities that are or will be conducted by the firm or its partners, such as firm-NGO partnerships, extending the concept by incorporating cross-sector collaborations, and viewing business models as generators of social value, not only economic value (Dahan et. al. 2010). Partnerships are pathways for different organisations to contribute to the success of each other's business model by undertaking complementary activities in the completion of a production system or via a second mechanism where they jointly create a novel business model that drives both organisations' activities.

These are possible configurations of business relationships that recognise value in complementary and cooperative action, potentially enabling firms to strategically contribute to shaping associates' and indirect stakeholders' capabilities. The literature on business models recognises their usefulness for creating taxonomies or typologies of firms. The business model provides generic ways of differentiating firms based on new ideas, new empirics, or new business experiences that become important so that different elements can be analysed individually (Baden-Fuller 2010: p.160). Business models determine sources of value, cost and regulations that the firm needs to address, make sense of the configuration of a firm's activities and shape the organisation and its relationships.

In the case of profit-seeking firms, the function is determined by a continuum of values in Rhinish collaborative approach in the national economic system such as that practices in Japan and Germany (Hall and Soskice 2003) - see in further detail in section 2.9 below - or the classical economic drivers aiming to solely maximise utility, lower costs and redistribute financial value among shareholders characteristic of Anglo capitalism. Under this understanding, business routines are the activities, resources and processes that link each component of the business model to the firm and outwards through their relationships with their associates and stakeholders.

These routines include human resources policies, investment and deployment of technology, production inputs or material resources routinely utilised by the firm to create value. These different relational aspects of the business model and its routines propose a conceptual rather than financial model of a firm (Teece 2010: p. 175), providing the entry point for firms to be described and classified, and to operate as sites for scientific investigation (Baden-Fuller and Morgan 2010). The business model is a unit of analysis distinct from the product, firm, industry, or network; it is centred on a focal firm, but its boundaries are wider than those of the firm. This supports the relational framework proposed by this study, moving from a firm centred analysis to a system of stakeholders.

2.3 From mitigation to adaptation

Climate change mitigation and sustainability literature provides a precedent for examining the changes that firms can undergo by introducing new technologies, new knowledge and innovation which can assist in understanding the integration of adaptation into business models. The climate mitigation agenda has focused on supporting the private sector in reducing energy consumption and moving towards sustainability (Benn at al. 2014; Sathaye et al. 2007).

The IPCC has identified interconnections between adaptation and mitigation actions, finding that implementing adaptation measures has implications for mitigation options and vice versa (IPCC 2012: p. 747). This inter-relationship manifests in the trade-offs or synergies between both types of responses to climate change. Climate change mitigation is indirect prevention of future damage, while adaptation seeks the adjustment to actual or expected climate and its effects (IPCC 2014).

The result of mitigation measures in the private sector has been the creation of markets for carbon offsets, new technologies and more easily quantifiable energy reduction. However, the adoption of adaptation actions and the contributions of the private sector are less clear and have only begun to be documented and understood (Pauw and Pegels 2013).

In climate mitigation, the actions required (though arguably not sufficient) have often been communicated to firms through the market. Firms have incorporated climate change mitigation actions into their business models when seeking new opportunities, such as new markets, financial mechanisms or subsidies that have necessitated alterations to certain routines within the firm. Incentives that result from these activities, including added reputational value that differentiates the firm and increases competitive advantage in the market, have been proven to prompt behavioural changes in firms (Hottenrott et al. 2016; Rexhäuser and Rammer 2014).

Eco-innovation in the private sector has helped firms engage in mitigation actions to reduce costs, capture opportunities and improve their social reputations (Osterwalder 2010). Individual firms adopted and integrated mitigation measures into their operations by gradually finding ways to reduce their CO2 and optimise energy consumption. This occurred by shifting to renewable energy technologies or innovating by utilising eco-friendly alternatives (OECD 2012; Dunn 2012; IPCC 2011; Johnson and Suskewitcz 2009). It was possible to promote adoption when individual firms recognised the value of integrating mitigation activities into their operations through strong market signals and incentives created by national governments, the United Nations climate change regime of organizations, including the UNFCCC, the emergence of low cost technologies for energy and water efficiency and emerging market pressures from consumers that increasingly call for forms to move towards sustainable practices.

Leveraging the knowledge or resources identified through the experience of investing in mitigation may inform the adoption or integration of adaptation strategies. Climate change measures in firms do not happen in a vacuum and overlaps, synergies and complementarities between mitigation and adaptation responses in the private sector have been established (Verchot et al. 2007; Klein et al. 2007; Klein et al. 2005).

Although these are still emerging areas of research, some examples can be found in the agroforestry sector where farming systems can enhance carbon sequestration (Nair et al. 2009) and diversify ecosystems to improve land management practices, or in the energy sector where renewable energy and remote energy generators can also allow remote communities and firms the ability to increase the stability, reliability and security of their energy supply (Morand et al. 2015: p. 6).

The contributions of individual firms to mitigation have been clearly established through the sustainability agenda, clean energy and environmental forms of corporate social responsibility, including green development mechanisms. The medium and large business firms that have engaged in the climate change agenda have focused on reducing their greenhouse gas emissions to mitigate climate change (UNGC 2011). The interests of the private actors in mitigation activities have been incentivised by business innovations, green technologies and new investment opportunities. These include sustainability practices, carbon and emissions trading and energy efficiency (Wittneben et al. 2012).

In contrast to adaptation, the mitigation agenda's objectives have been more readily adopted and understood by businesses. This is because mitigation opens avenues for investment and cost reduction in the production of goods and delivery of services, as well as facilitating access to new sources of material and non-material resources, such as finance and technical assistance (Popp et al. 2010; Johnstone et al. 2010; Jaffe at al. 2002). The signals of the mitigation agenda have provided private firms with incentives that allow them to draw value from related actions. Mitigation has been adopted by a wide array of different sized firms from a variety of sectors, leading to increased efficiency and innovation. The adaptation agenda, however, is more emergent and possibly more challenging, though it has the potential to build on disaster risk management experiences in the private sector.

Many firms undertake adaptation to protect stock, physical assets and investments from extreme events. Insurance mechanisms are being increasingly relied upon (Mills 2004) to reach the productive assets of primary sector businesses through weather derivatives that release funds once rainfall is below a specified threshold. The business continuity management protocols provide an architecture for managing the soft impacts of shock events firms recognize that disaster risk management is key to business continuity and competitiveness.

This requires that firms assign resources to rethinking business routines to minimise the consequences from disasters. While these investments might be viewed as burdensome, incorporating disaster risk and climate change adaptation planning therefore will need to address this challenge to encourage firms to move beyond normal risk management demarcations.

Then it will be critical to establish a common language across the firm's organisational and value chains, where managers and officers are supported by a common framework at all levels of the organisation (Johnson and Abe 2015) for coherent and complementary adaptation planning.

The move towards a more comprehensive integration of adaptation planning might originate from market signals due to recurring losses, or when the cost of adaptation outweighs the cost of inaction. However, alternative entry points and sources of innovation might introduce new information and generate knowledge capable of reframing business routines towards social forms of adaptation, which can allow a broader distribution of the risks, impacts and opportunities of climate change.

These processes will likely require new forms of collaboration across a firm's internal departments and external relationships (UNISDR 2014; APEC 2013; Twigg 2001). In the private sector, business continuity planning is one mechanism already in place with a common business language that takes into consideration emergency planning for disaster events, as these are disturbances to business operations (Li 2015).

Businesses can also benefit from adaptation investments by the State in the design and maintenance of robust physical infrastructure – including in the transport, energy, communication, water and security sectors – to protect business functioning during weather events.

It is expected that firms will directly depend on the public sector (including international organisations) for information, policy, regulation and knowledge on climate adaptation (Biagini and Miller 2013: p. 243). Individual firms will benefit from these public good investments – a public provision of public good for largely private benefit – in adaptation, which indicate their connectedness to wider systems of production and investment (Tompkins and Eakin 2012). This thesis argues that firm investments in adaptation can go beyond the short-term benefit of the business to yield direct and indirect benefits to the firm and more broadly, which can lead to improved community relations and longer-term co-benefits (Global Compact 2012), but these have not yet been properly understood, nor have the incentives been identified in the literature.

2.4 Firm adaptation to climate change – a firm-centric view

The current knowledge of private sector climate adaptation reflects a firm-centred approach to understanding the responses of medium and large-scale firms to climate change impacts. This method is used to develop a relational view of firms and their associations as adaptive systems. The literature on firm-centred adaptation can be clustered into studies that analyse impact and climate risk (Nitkin et al. 2013: p. 25 citing McBoyle et. al. 2003; Scott and Jones 2006; Scott and Jones, 2007; Scott et al. 2006; Scott et al. 2007; Hennessy et al. 2008) and those that examine the drivers of firm adaptation, including motivations (Mendelsohn 2000); and others that focus on organisational learning and social learning in order to understand firm behaviour (Arnell and Delaney 2006; Berkhout 2008; Pelling 2008).

These studies are centred on the firm's capacity to respond to climate change risk and its impacts as part of organisational life across all industries (Hoffman 2006; Hoffmann et al. 2009; Wilbanks et al. 2007; Haggar and Schep 2011). Climate risks will differ from pre-existing environmental hazards because of the nature of global impacts and the way in which these can affect business across the globe, even when firms are not physically located in vulnerable areas (WBCSD 2015). For example, Haggar and Schep (2011) found that stakeholders in the coffee production value chains in Guatemala, Brazil, Tanzania and Vietnam already perceive changes in coffee production linked to changing climate conditions and predict that large changes will occur in total net production over the next 40 years.

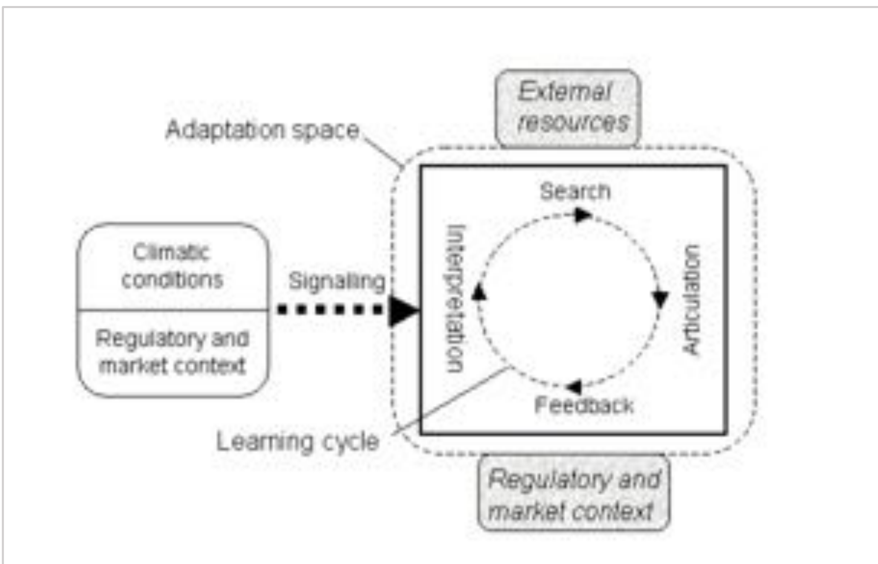
2.4.1 Organisational learning

Organisational learning theory suggests that learning involves processing and coding routines within organisations that draw on experiences leading to changes in organisational behaviour (Berkhout 2004 citing Chakravarthy 1982; Aldrich and Auster 1986; March 1991; Staber and Sydow 2002). These routines might be modified or expanded when existing ones have proven unsuccessful, or when alternative routines with greater advantages are discovered (Gavetti and Levinthal 2000). Organisational routines are comprised of rules, procedures, strategies, technologies, conventions, cultures and beliefs around which organisations operate (Berkhout 2004: p. 7). They can be influenced by both internal factors, such as leadership, and external factors, including the business environment, climatic risks and new opportunities.

The organisational learning model for climate adaptation proposed by Berkhout (2004) presents four stages within an organisational learning cycle (see Figure 3 below): 1) signalling and interpretation; 2) experimentation and search; 3) knowledge articulation and codification; and 4) feedback and iteration. This model outlines the learning cycle and the stages where external signals may trigger new routines. In this way, responses are given to climate stimuli and market opportunities and incorporated into the internal processes of the firm, becoming part of the (adapting) business model.

In the next section, the degree of adjustment through the learning cycle will be linked to the learning loops frameworks, where minor increments through actions lead to first loop learning, a reframing through strategies lead to double loop learning and triple loop adjustments include a wider context towards more transformative changes. These learning cycles provide an analytical lens to locate adaptive actions and the changes triggered through integration of new information or knowledge into the internal system of the firm or business model.

Figure 3 Organisational Learning Model. Source: Berkhout et al. (2004)



In the first stage, the learning process is initiated by a signalling mechanism that challenges existing routines as inappropriate or ineffective. These signals can arise from climate change, weather extremes, the market and/or regulations, triggering an organisational learning process. The signalling itself results from a stimulus, which

Eisenack and Stecker (2013) define as a change in biophysical variables associated with climate change, though this could also be a change in risk tolerance even when biophysical variables remain unchanged; for example, if new knowledge is made available on the dangers of climate change.

The second stage is characterised by searching and experimentation (Zollo and Winter 2002). This learning process internalises the stimuli. Success depends on the internal actions of the firm and its ability to interpret and act on external signals. The third stage further articulates the newly formed knowledge and codifies it so that it is normalised into a firm's routines. The firm selects options from the trial and experimentation stages and disseminates the new adaptive processes across the organisation, which leads to the establishment of new routines. The fourth and final stage focuses on feedback and iteration. This is the on-going process within the cycle of validation that examines the firm's response to external stimuli and confirms the organisational effectiveness of the new, chosen routines.

The mechanisms for dissemination and codification of new routines vary according to the range of the stimuli and the investment in the trial and experimentation stages that set out the options for codification into operations. These can include the creation of operational manuals to alter processes, the development of communication hierarchies for emergency or disaster risks identified in field operations or the integration of technological platforms customised to relay information necessary to undertake adaptation actions.

In business planning, climate change is just another factor for risk assessment. Rarely is it a central concern, though it might be an emerging area of interest for corporate strategy and planning (Winn 2010; Schwartz 2007). Firm strategies continue to focus on established forms of assessing risk and innovation (Wittneben et al. 2012), which rely on cost calculations and market variables to determine opportunities, costs and value of investments. The signals that prompt firms to make adjustments to their routines originate from a combination of climatic conditions, regulation and the market

(Berkhout 2004). Stimuli or signals from climate change are difficult for firms to interpret because they remain outside their normal operational routines and strategic planning cycles (Bazerman 2006; Gifford et al. 2009; Hoffman 2009).

Firms tend to "*overlook distant times, distant places, and failures*" (Levinthal and March 1993: p. 95), which become salient barriers to developing adaptive capacity (Winn et al. 2011). The roles of policy and government lie in promoting longer-term views and planning cycles and acting as coordinating agents, which will be key to achieving any potential long-term, effective adaptive capacity (Mendelsohn 2000). The interconnected economic reality of globalisation can rapidly transfer the impacts of climate in distant times and places to the local level, creating vulnerability emerging from the global political economy (Pelling and Schipper 2006). The risks in one region can cascade to neighbouring countries, as is demonstrated by climate migration or increases in global prices of food staples because of the loss of agricultural produce. While adaptation must respond to local risks, it can also be understood from its relationship to a global process that intervenes in the distribution of interconnected winners and losers (O'Brien and Leichenko 2000).

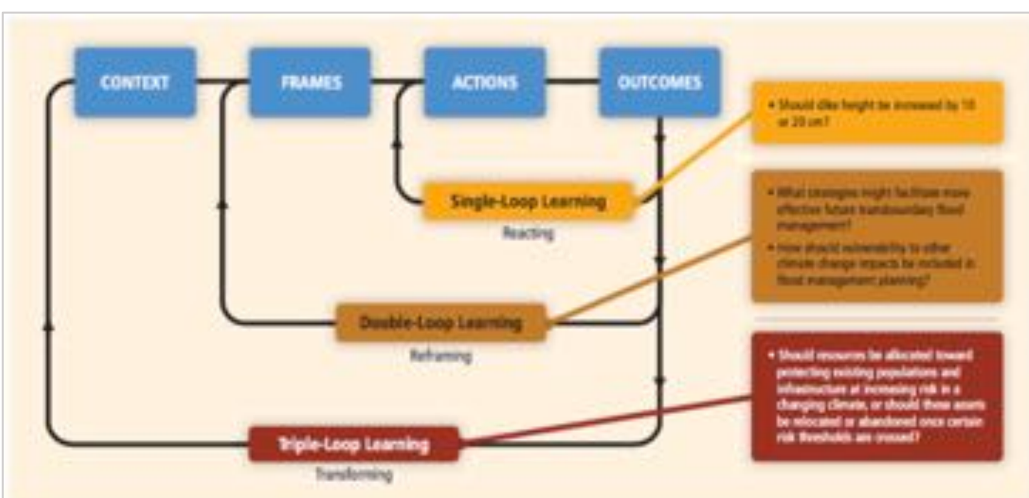
A key element missing from the different studies on organisation responses to climate change is time. This is a necessary feature to unpack in the context of adaptation responses and resource use for adaptation by firms. The dimension of time is proposed by Ancona & Chong (1996: p. 253) by developing the concept of *entrainment*, which is defined "*as the adjustment of the pace or cycle of an activity to match or synchronize with that of another activity*."

This refers to the initial response of the firm, where one activity in the cycle occurs in response to climate stimuli (reaction speed), followed by the speed it takes the organisation to synchronize with the external activities (implementation speed). The firm learning cycle begins with a stimulus, but the reaction speed might occur in the next corporate planning cycle, or by the end of harvest season in agriculture, for example, when the losses from climate-related impacts are calculated. The implementation speed will depend on the ability of the firm to adjust or reconfigure the business routines to cope with increasing climate changes in those locations where stimuli are recognised. Schmitt and Klarner (2010) recognise that firms with longer-range perspectives can acquire diverse information from experience, current routines and future contexts to challenge their knowledge structures, allowing for better recognition of environmental changes than in firms applying shorter-term perspectives.

2.4.2 Adaptation and learning

The learning process can also be conceptualised for climate change adaptation processes through the literature on learning loops. This refers to adjustments and changes determined by the degree of learning feedback in a system. The loop learning model proposed by Kolb and Fry (1975) in figure 4 below, divides learning processes into three learning loops, providing an analytical framework to understand the pathways for adaptation actions undertaken by firms.

Figure 4 Loop Learning Model. Source: IPCC SREX Report (2012).



In the first cycle, a single loop leads to amendments to specific organisational instruments that improve the efficiency of an action (Pelling et al. 2008). In business routines, for instance, these can be minor adjustments to transportation routes or schedules to avoid delays or costs from natural hazard-related impacts. The single loop actions are procedural adjustments limited to minor corrections using on-site information. These changes likely would not require additional resources or coordination with senior planners in the organisation. This limits the ability to recognise and document adaptive actions, due to the implementation speed of short-term routine corrections in response to perceived weather or natural hazard impacts. Single-loop learning is insufficient to undertake significant long-term corrections to solve growing climate-related stresses.

Double-loop learning challenges fundamental organisational values and policies. These adjustments result in more profound changes in a firm's behaviour. For example, in agricultural supply chains, the firm can establish clear protocols for the use of water sensors or irrigation cycles to manage water resources. These protocols would include training for onsite coordinators and the establishment of feedback loops to track the efficiency of these measures. Additionally, incentives for change and monitoring would be introduced into operational meetings to maintain close collaboration between senior managers and operations. Double-loop learning is a starting point to understand climate-related failures in the context of a broader changing climate system. The experiences of losses, both in productive assets and opportunities to create value for the firm, might trigger important changes in its norms, policies and objectives through adaptation (Argyris 1977).

Triple-loop learning opens scope for deliberate transformative change as it is learning that challenges underlying organising principles (Pelling et al. 2008), raising issues related to power, relationships and institutional arrangements and determining a range of possible course of actions. In business models these changes would be those that propose fundamental reconfigurations and transform business drivers, objectives, business routines and relationships with associates. Triple-loop learning in business model framings would imply integration and recognition of adaptation as a social process, and lead to fundamental changes in the way the firm extracts value and seek marginal costs.

While triple-loop learning implies no normative preferences, there is scope for a progressive trajectory. This would require recognising the adaptation needs of social actors within the scope of firm relationships. For example, understanding the limits of agricultural output in certain locations and investing in the relocation of critical assets or developing common adaptation strategies with local associates. Thus, triple-loop learning describes pathways through which the firm might come to better recognise its social embeddedness in local economic life and renegotiate its social function within the local production system. This would involve implementing longer-term adaptation strategies geared towards enhancing the adaptive capacities of the organisation itself and the local system. Triple-loop learning describes a relational view of the firm in the context of climate change adaptation.

2.5 Firms (influence) in adaptation – a relational view

Recent literature recognises that the adaptation agenda has only just begun to identify the role of the private sector and its contributions to adaptation processes (Pauw and Pegels 2013; Biagini and Miller 2013). The latest studies draw on lessons from the development agenda to explain the benefits, mechanisms and contributions possible from the engagement of private sector actors in communities.

This section begins to direct thinking on private sector adaptation responses towards a relational view of the firm. This fills a gap in the literature by widening the analysis of adaptation from organisational changes in a single firm to a system-wide process. The analysis of relational spaces of individual firms and external associates under climate stress allows research to analyse different communication and relational pathways as avenues for the exchange of information and resources that shape development.

This theoretical approach includes stakeholder theory, which widens analysis beyond firm responses to consider external actors, however stakeholder theory considers external actor's that are critical to the functioning of the firm, it remains an approach driven by firm interest, seeking to understand the organisation as it pursues or stabilises economic gains while under climate stress. Also employed are the variegated capitalism and assemblage theories, which allow for the examination of adaptation and resource deployment under a lens of economic agency through which coordination or competition facilitate or limit adaptive capacity. The firm-centred analysis then expands outwards in spaces and geographic locations under climate stress where a wide array of resources, information, actors and space are changed, assembled and mobilised under the influence of a variety of local actors.

2.5.1 Stakeholder theory

Stakeholder theory expands the firm's sphere of influence to consider individual actors that would be affected by or affect its operations. Stakeholders are defined as those individuals or groups that have a stake in or claim on the firm: suppliers, customers, employees, shareholders and, in some cases, the local community (Freeman, 2012). In their earliest work, Freeman and Reed (1983) proposed both a narrow definition that referred only to those groups vital for the survival of the firm and a wider definition that included those that can affect or might be affected by the behaviour of the firm.

The central thesis proposed by Freeman states that the organisation of firms consists of a nexus of contracts or formal relationships between the owners of the means of production and other actors, and that each of these groups has the right not to be utilised just to achieve an end but should also participate in the management of the firm. This argument still focuses on the function and performance of an individual firm; it is limited to a firm-centric view of the ways in which these organisations can be steered by contrasting interests and by the resolution of potential tensions with external actors. It is, however, a useful concept to consider in developing the analytical framework of this thesis, as it provides another element that sustains the expansion of the analytical boundary of organisational responses to climate impacts to consider relational processes in the face of climate extremes.

Organisational and management studies on firms' responses to climate change are limited by the tendency to isolate firms from social and political contexts. This isolated view of business firm's limits understanding of the relational aspects of their operations. Hall and Soskice (2001: p. 6) differentiate firms according to the "*type and quality of the relationships the firm is able to establish both internally with its own employees and externally with a range of other actors such as suppliers, collaborators, stakeholders, business associations and government.*" The firm's "capability is ultimately relational, and its success will depend on its ability to coordinate effectively with a wide reach of actors" (Hall and Soskice 2001: p. 6) to solve external challenges. Recognizing the interdependence between these actors is central to adaptive processes in vulnerable regions, as attention has been called to the fact that no single actor will be able to respond to climatic impacts in isolation (IPCC 2014).

2.5.2 Firm contributions to adaptation

Individual firms will seek adaptation in climate-sensitive sectors when "the cost of inaction outweighs the cost of adaptation" (Nitkin 2013: p. 25 citing Mendelsohn 2000). Firms seeking to adapt can therefore narrow their analysis of potential actions solely to their capacity to implement them, rather than looking to the effects of their adaptive actions on external adaptation processes. However, their actions can positively contribute to adaption more broadly, and Biagini and Miller (2013) highlight areas of possible contributions by drawing from the Least Developed Countries Climate Fund (LDCF) projects portfolio implemented by the United Nations Development Program (UNDP). These include:

- Awareness raising, including potential risks and response measures from business perspectives;
- Building the capacity of other firms and organisations;
- Activities that change regulation, policies and institutional infrastructure in local contexts;
- Public-private partnerships and efforts that promote private sector responses to climate change; and
- Entrepreneurship development that opens new private sector opportunities for reducing climate vulnerability.

In listing these activities, which were identified from donor-led programming, no insight was provided into the processes and decisions that led to these contributions and engagements. Any mention of specific beneficiaries from the adaptation contributions of firms was omitted, as was the rationale used in pursuing adaptation. This is critical to determining why firms deploy resources for adaptation, how these resources are used and the role of beneficiaries in determining the use of these resources in ways capable of shaping adaptation trajectories.

Firms' deployment of resources as part of adaptation actions can contribute to developing broader dimensions of adaptive capacity among associates, including investments in employee education, income and health (IPCC 2007). When firms allocate resources to respond to specific climate impacts, such as local drought or floods in host communities, for instance, their resources may contribute to improving local institutions, promoting knowledge sharing or diffusing technologies for adaptation (Yohe and Tol 2002; Downing 2003; Brooks et al. 2005; Tol and Yohe 2007).

The contributions of firms to the adaptive capacity of host communities, employees or other stakeholders could occur at different scales. There are immediate contributions, such as building new infrastructure as a form of business model led adaptive actions while providing cost sharing mechanism with local stakeholders. For example, an organic vegetable firm in Nicaragua identified increasing climate risks and built new greenhouses in locations of high risk, which the firm allowed local small farmers in their supply chain to utilise to grow certain quantities of crops to achieve minimum harvest levels to maintain household livelihoods (See "UNFCCC Private Sector Initiative case study – Chiles de Nicaragua" in section 3.2).

Global firms can also act through local organisations, such as governing institutions or NGOs, to contribute to adaptation and improve local capacity. In the case of information technology, for example, firms like Google are working with NGO coalitions to develop mapping tools that will facilitate community stakeholders' access to information such as climate data. In another example, IBM tested a system of sensors to monitor the stability of flood protection dikes through the collection and analysis of weather, rainfall and water-level data. This data has been used to advise local governments and emergency responders about flood threats and evacuation plans (Forstater el al. 2009).

Several types of private sector contributions to adaptation, include firm's engagement participation in climate change policy consultations or decision-making processes, helping improving disaster risk regulations, promotion of heat wave awareness and vector-borne disease awareness among employees and families, Provision of in-kind donations or cash crops programs and addressing vulnerabilities through early warning systems, disaster recovery programmes and reducing risk exposure by enhancing coastal and flood defences, including natural ones that also help to enhance ecological resilience. These activities, contributions and stakeholders will be further explained and analysed in Chapter IV.

2.5.3 Drivers for firms to contribute to adaptation

There are two ways in which firms adapt to climate change: 1) by building adaptive capacity, and 2) by implementing adaptation decisions, which effectively transforms capacity into action (Adger et al. 2013). Actions could include, for example, developing or adopting technology, improving risk management or knowledge enhancement (West and Gawith 2005). These kinds of actions can adjust firms' internal routines or support external associates or stakeholders, and could take the form of investments, the diffusion of information, or system-wide action.

According to the International Finance Corporation (IFC) (2013), there are five main areas to consider as drivers and barriers to the private sector's engagement in adaptation, where a combination of these factors can motivate businesses to respond to climate stimuli or explain failures to incorporate adaptation strategies into business models:

1. *Data and information*, including availability of and access to projections, impacts, metrics, costs and benefits and analysis of community vulnerability and risk. These assessments will depend on the collection and use of climate information, recognition of potential uses for new technologies and understanding of the wider social environment in which the firm operates. 2) *Institutional arrangements*, which are made up of government coordinating agencies, the private sector and other economic brokers and civil society actors. These formal arrangements can also include universities, training centres or partnerships with suppliers and help to ensure mutual economic stability in the face of increasing climate threats.
2. *Policies*, which include building standards, zoning rules and public infrastructure, investor relations and/or stakeholder engagement. These drivers will depend on the potential to work with local or regional authorities to develop adaptation planning suitable to the firm, managing investor expectations, communicating

climate risks without losing investor confidence and participation in local activities related to climate planning.

3. *Economic incentives*, such as those provided by government and those created by financial instruments, including environmental trading markets. These are financial resources available to firms that might enable them to undertake new adaptation measures or implement new technologies, train employees or utilise subsidies to manage losses from climate impacts. This includes all adaptation finance mechanisms and funds available in the market.
4. *Communication, technology and knowledge,* including training, user applications, knowledge transfers and new tools to assess diversification options and alternatives. This also comprises more usable forms of information technologies, the improvement of ground communications for disaster or climate risk management and potential modelling or planning for specific geographic locations or climate patterns that might impact business operations.

These drivers would require an initial recognition of climate impacts and acceptance of the need to undertake adaptation. While the availability of information or data, technology and incentives might exist in a given policy environment or through local government services, firms might not necessarily undertake any form of adaptation planning or connect climate-related losses to strategic actions on adaptation. These drivers can also be considered as variable in terms of initial firm capability, size and economic sector, the ability of a small or medium enterprise to introduce new tools to assess adaptation options or find the way to interpret available climate information.

These drivers will vary according to the particular interests, routines and business cycles particular to each firm. The IFC (2013) recognises that, at the core, what motivates private sector adaptation actions is maintaining or increasing value (whether revenues, credit, reputation), keeping costs down (limiting losses, damages, interruptions to operations and business) or following relevant regulation and policies. These dimensions are the building blocks of their business models. Each must be considered when analysing the components of firms' adaptation efforts and their consequences for associates. The drivers again are fundamentally oriented towards a capital centric function of the firm, ignoring drivers that might trigger change or motivate adaptive behaviour emerging from a social learning experience or cooperative forms of engagement, where neither immediate value creation is guaranteed, or benefits might not directly accrue to the firm deploying the resources for adaptation.

2.5.4 Benefits for firms to contribute to adaptation

An emergent body of literature outlines the many benefits that firms stand to gain from taking communities into account when assessing climate change risks, opportunities and adaptation options. Oxfam America (2012) argues that from a firm's perspective:

1. Understanding risks faced by a community can provide useful insights to the firm's own vulnerability, risks, opportunities and adaptation;
2. There could be an effect on the social licenses to operate if nothing is done to maintain social and/or environmental performance under different climatic conditions;
3. By considering community concerns over the sharing of resources, potential conflicts can be avoided and/or mitigated;
4. Poorly planned adaptation could lead to maladaptation and negative consequences on local communities; and,
5. Adaptation creates a new source of 'shared value' opportunities

Individual firms might decide to look beyond their established business planning horizon to understand the risks faced by the community, and particularly those that might affect their employees and their households, local schools or other institutions, as these may require the firm to divert resources to a variety of different programs aimed to improve climate adaptation capabilities, disaster resilience and responses. Anticipating these different community risks and potential avenues of response can improve the firm's understanding of its operational environment and allow planners to develop minimum measures to manage these risks.

When these risks are ignored, the ability of the firm to maintain operations during times of stress and shock might depend on the establishment of routines or use of resources that may be perceived by the community as infringing on moral behaviour. Firms that utilise resources to maintain stable business operations without considering community adaptation needs risk their social licence, specifically in locations where the firm is strongly embedded into local social and economic fabrics. This could lead to tension or confrontation with residents over resources or solutions that seem efficient to the firm but may deteriorate – or be perceived to compromise – local adaptive capacities.

Viewed more positively, adaptation can bring shared value through the implementation of measures that result in win-win outcomes for the firm and its associates. These positive, shared benefits can include enhanced natural capital from measures including the restoration ecosystems as naturally protective floor barriers; enhanced social value through programs that develop local capacity for disaster risk management or technical advisory activities; or enhanced financial value through actions such as the provision of in-kind contributions of food or income insurance to employees and suppliers during natural disasters (Izumi and Shaw 2015).

The possibility of co-benefits informs the analytical framework of this thesis. Co-benefits describe adaptation outcomes that are shared between the firm and its external associates. These benefits translate into the creation of value, which is a central element of business models, presenting another set of factors that helps to draw the research away from firm-centric responses to climate impacts to a more systemic and relational perspective. The benefit to firms of contributing to the adaptive capacity of external stakeholders has also been reviewed by the Global Compact (2012), an international voluntary initiative based on CEO commitments to align firm strategies and operations with the Sustainable Development Goals. The network helps build capacity across the private sector and has outlined some of the benefits to firms of engaging in adaptation, however these remain firm centric and based on economic incentives to leverage the firm's capacities towards adaptive behaviours:

- Increased ability to mitigate and manage risk
- Assured continuity of operations (for example, by avoiding damage to assets or interruptions in supply of inputs)
- Financial benefits (either due to lower costs or new revenue streams)
- Expansion into new markets;
- Reputational benefits with external stakeholders, including continued social license to operate and meeting current (and anticipated) customer expectations
- Competitive edge over companies that are failing to respond to climate change challenges
- Possibility to leverage and expand adaptation efforts by accessing new public financing streams earmarked for climate change adaptation

The case studies presented in Chapter VI of the thesis provide examples of the different types of adaptation projects of individual firms. These projects will have underlying drivers mentioned above in their deployment of adaptation solutions and measures. The benefits remained with a focus on firm-centric assumptions and the logic of the selfish behaviour of firms, where stakeholders and associates are positioned as essential parts of economic value chains for firms. It is through these value chain relationships – the provision of key resources to firms, such as a workforce, essential supplies, a customer base and the social license to operate (IFC, 2012) – that associates are brought into the economic logic of the firm and, by extension, its adaptation planning.

The Global Compact (2012) found that many companies understood that some of their actions made strong contributions to enhancing the long-term climate resilience of the company and vulnerable communities. However, firms tended not to categorize and communicate these contributions, but rather name them as 'sustainable supply chain management,' 'disaster risk reduction' or 'community engagement projects' in company or external communications (UNGC 2012).

These benefits point to relational aspects in the context of climate adaptation. While coordinated activities can be considered joint adaptation rather than the sum of private adaptation responses, relational aspects also encompass more informal interactions and impacts (Mendelsohn 2000). Local networks, relationships and patterns of reciprocity and exchange are therefore paramount to building adaptive capacity (Rodima-Taylor 2012).

2.6 Mechanisms of Firm Engagement in Climate Change Adaptation

The IPCC (SREX 2012: p.347) recognises that the deliberate actions of the private sector that contribute to adaptation can arise from three forms of engagement: (1) corporate social responsibility (CSR), (2) public private partnerships (PPP) and (3) business model approaches. This section establishes that CSR and PPP approaches are subordinate mechanisms embedded within a firm's business model. These forms of private sector engagements in adaptation can be explained by understanding business drivers and traced to the different internal processes and routines dictated by a firm's business model. These mechanisms have different limits and opportunities and will different in how they allow for flows of resources and information between different associates and stakeholders in each modality. The descriptions below are informed by normative and empirical studies in recent international development literature.

2.6.1 Corporate Social Responsibility (CSR)

The CSR is a mechanism through which firms engage in sustainable development activities (Blowfield and Frynas 2005; Hamman and Acutt 2003). This form of engagement is closely tied to firms' interest in promoting a self-regulatory regime in the international economy (Reed and Reed 2011). It has resulted in the creation of multiple types of certification and self-accreditation from business organisations, such as ISO 26000, which is a standard from the International Standardisation Organisation (ISO) that provides guidance to firms on social responsibility without any requirements for compliance.

Firms use this approach to gain social license from the communities within which they operate (Blowfield 2005; Jenkins 2005; Frynas 2005), but development gains from these types of actions often fall short of meaningful and sustained contributions to social and environmental objectives (Frankental 2001). It has been up to development organisations and governments to promote forms of engagement by businesses that contribute more effectively to social development and sustainability objectives (Thorpe 2014; Knorringa and Helmsing 2013 2012; Davis, 2011; Mukherjee 2009; Nelson 2011 2006; Covey 2001).

The private sector can distance business practice from the normative ideals of sustainable development by refusing to internalise social and environmental concerns in their business operations (see Reed and Reed 2011; Wittneben 2012). This strategy demonstrates the issue of pursuing narrow interests like shareholder value creation and the similarly narrow operational boundaries this necessitates, while preserving a self-regulating regime through piece-meal contributions to external but critical problems.

Climate change is one example of a problem treated as a CSR exercise by many firms (Wittneben 2012), where firms have taken soft approaches limited to the instruments of corporate marketing. Blowfield (2000) argues that CSR practices leave the fundamental principles of the capitalist firm intact, such as the maintenance of profit seeking and economic growth as dominant values, which therefore weakens the contributions made through this mechanism when presented with values that challenge the nature of the business activities themselves. The CSR activities of large firms are distributed among a diversity of areas related both to the environment and sustainability, and smaller firms might engage in diverse social responsibility initiatives, but a consolidated statistic or the number of contributions is possible to capture, as different countries will have various forms of corporate engagements to social or environmental objectives.

2.6.2 Partnerships

The origin of the partnerships mode of engagement can be traced to public-private partnerships (PPP) in the sphere of public procurement for infrastructure projects (De Clerck 2012). PPPs entail a transfer of responsibility for the performance of a public task to a private actor (BMZ 2009), with the necessary resources, such as expertise, equipment and capital, being jointly organised to achieve an overall objective of efficiency in the delivery of a public good. There is a vast literature on PPPs. However, this section is focused on partnerships for sustainable development, which began to emerge after the 2002 World Summit on Sustainable Development in Johannesburg (M.M Van Hujstee et al. 2007; Eweje 2007; Norris 2005; Hens & Nath 2003). During this meeting, State, private sector and civil society actors reaffirmed their commitment to balance economic growth, social development and environmental protection as the core tenants of sustainable development (WSSD 2002), recognising the importance of partnerships and coordination to achieve these goals.

Partnerships for sustainable development are a subset of PPPs and can be defined as "*collaborative arrangements in which actors from two or more spheres of society (State, market and civil society) are involved in a non-hierarchical process, and through which these actors strive for a sustainability goal*" (Van Hujstee et al 2007: p.77). This indicates a move towards a different segment of the organisational spectrum according to the organisations' functions. While the firm might not shift their entire structure, internal components, including learning practices, can shift position to align with goals and relevant factors beyond economic calculations. The partnerships mechanism implicitly recognises that no single actor could tackle the challenges presented by sustainable development and attempts to reconcile previously separated responsibilities: the private sector was focused on economic growth and development, while the State protected public goods, including social and environmental capital (Glasbergen and Groenenberg 2001).

Box 1 Example of Sustainable Development Partnership. Source: UNGC-UNEP (2012: p.17)

CeTaqua: Building the adaptation knowledge base for water resource management.

In 2007, the firm Agbar joined with the Polytechnic University of Catalonia (UPC) and the Spanish National Research Council (CSIC) to found CETaqua. CETaqua contributes to research and development of technologies linked to the water cycle, striving for synergies between the business, research and education sectors to meet pressing water-related challenges at the national and global levels. Under its global change priority, CETaqua is currently examining two aspects of adaptation:

1) Adaptation in water resource management: The institute is developing methods and tools for modelling the impacts of climate change and other aspects of global change on water resources. The goal is to estimate future impacts and propose and evaluate measures for adaptation at the basin level in areas facing heavy use by people and industry, using Spain's Llobregat River basin as a locus for research.

2) Adaptation in flood risk management: CETaqua aims to improve flood risk prevention and prediction in planning, evaluate the probability of extreme weather events in a context of climate change and analyse the adaptability of current infrastructure and management models to identify improvements for enhanced resilience against future floods.

The Box 1 above describes a project that leverages the capabilities of multiple organisations to address water resource problems. One organisation provides technical tools, whereas complementary work on policy linkages is undertaken by the government research council. There are a range of actions in which private actors could engage in this mechanism of partnership, which could be directly with government agencies or with civil society NGOs.

The actions taken in partnership could range from helping to set agendas (Streck 2002b; Visseren-Hamakers & Glasbergen 2007) to program implementation (Reinicke & Deng 2000; Streck 2002b) or the generation and dissemination of knowledge (Reinicke 1999; Reinicke & Deng 2000; Streck 2002b; Waddell 2002; Pattberg 2004). The incentive for firms is the temporary convergence of their interests with public sector objectives. This creates the notion of partnership between the private sector and the State but retains the separate and independent categories of each actor, as they partner solely for a specific project (Buckley 2012). In this mechanism cooperation is temporary and dependent on the partnership's objectives, where private sector firms can benefit from the expertise and knowledge of the local partners to enhance their capacity and develop creative and innovative solutions to accumulate new knowledge (Poncelet 2001; Hemmati 2002).

The motivation and incentive to partner is driven by the financial reward or temporary value that the firm can draw from the partnership. Art (2002) stated the importance of embedding the sustainable partnership model within the core business of the participating firm to achieve sustainable change. The limited temporal engagement and the peripheral linkage of the core business to the partnership and its objectives results in this approach being limited in its ability to influence long-term sustainability. This is particularly the case for desirable climate adaptation processes, which may require strategic and cooperative actions that does not overlap with the immediate interests of a firm.

According to Huijstee (2008) there are multiple motivations for partnerships which are informed by the functions attributed to this mechanism, some argue that increasing problems of globalization, both economic and environmental, exceed the capacity of single actors, in public or private sector, and partnerships become a new organizational forms and configurations between different actors to provide solutions through shared efforts (Van Herel 2005). Different drivers include the ability to set agendas (Streck 2002) or shape policy options on emerging development issues (Pattberg 2004).

The public-private partnerships model has been criticised for advancing the interests of individual firms and market logics under the guise of collaboration with the State and local communities (Miraftab 2004). Several authors have called attention to private sector firm engagement in sustainable development partnerships being convenient mechanisms to maintain independence and self-regulation in social and environmental problems (Glasbergen 2007). These critiques of self-regulation extend to issues of inclusiveness, democratic participation and the legitimacy of partnerships themselves (Pattberg 2004; Dubbink 2003; Meadowcroft 1998 and Blowers 1998). Here, public – private arrangements can privilege some parties, while excluding others on issues of public or common interests in local communities.

The partnerships themselves can be forms of eco-marketing aimed at satisfying consumer or client demands (Van Hujstee et al. 2007), helping individual firms differentiate themselves from competitors and gaining competitive advantages by creating reputational value or social licence, not unlike the CSR mechanism. A more critical view describes partnerships for sustainable development as a form of neo-corporatism (Richter 2003), where private decisions are preferred over public interests.

While the partnership mechanisms for firm engagement in sustainable development might be limited vehicles for leveraging private sector contributions to sustainability and, more recently, to adaptation (Kranz 2012; ICCR 2012), partnerships might also be an important pathway to introduce new information, norms and expertise to business models, leading to more fundamental changes in business routines or configuration of firm relationships.

2.6.3 The business model

The business model is often referred to as mechanism for contributing to sustainable development and disaster risk reduction. Management literature highlights value creation as central to business models from an economic perspective, while the development literature considers the ways in which business models can integrate social and environmental objectives and expand firms' value proposition (IIED 2009). The business model is mentioned as a vehicle to enhance private sector contributions to environmental and social capabilities where the CSR and partnership models have fallen short.

However, the guiding principles to address the challenge of incorporating social and environmental objectives into business models requires that firms recognise value as more than financial capital; it includes social and natural capital. The company must look beyond value creation and capture for itself and its customers to consider the importance of distributing value throughout the market chain and collaborating to design and implement business models (IIED, 2009: p. 2). The development policy literature provides examples that illustrate how firms have incorporated development-oriented actions into their operations and created value for the company and its the stakeholders. The box 2 below presents two examples from empirical work by Nelson (2013).

Box 2 Examples of Business Contributions to Sustainable Development. Source: Nelson (2013).

> "'Powering essential equipment in rural health facilities (VidaGás)' VidaGás is a Mozambique-based company, established with the primary goal of supplying the Ministry of Health with a dependable, affordable and clean fuel for powering essential equipment in remote health facilities. In addition to improving refrigeration, medical waste management and lighting, the increased use of propane gas by households in these remote communities also has environmental benefits and broader health advantages as a replacement for biomass fuels, while creating local income generating opportunities. Established by the non-profit Foundation for Community Development and Village Reach organisations, the company and its partners supply vaccines and other critical supplies while also tending to equipment repair and maintenance. They currently cover 87 health facilities, serving more than 1.5 million people."
>
> "'Harnessing free computing power for health and environmental research (IBM)' The World Community Grid program aims to create the world's largest public computing grid to make technology available to public and not-for-profit organisations for use in humanitarian research, which might not otherwise be completed due to the high costs of technical infrastructure required in the absence of a public grid. The model combines technological innovation with scientific research and large-scale volunteerism. It depends on organisations and individuals collectively contributing their unused computer time to perform computations that support a variety of health and environmental research projects. To date some 350,000 computers have been linked to the initiative."

In the field of disaster risk reduction, the Sendai Framework for Disaster Risk Reduction (SFDRR) (2015) also calls for businss model approaches to increase business resilience and protect livelihoods and productive assets throughout the supply chains of individual firms. This requires integrating disaster risk management into business models and practices. The SFDRR mentions the need for disaster-risk-informed investments; engagement in awareness-raising and training employees and customers; research and innovation; and technological development in the realm of disaster risk management. These activities would enhance firm capabilities but also require firms to share and disseminate knowledge, practices and non-sensitive data, and to actively coordinate efforts with the State at national, regional and local levels to improve technical standards that incorporate disaster risk management. New sources of funding for adaptation still lack the necessary empirical data, information and proof of successful experiments needed to justify financing corporate actions that leverage or modify this business model (Chesbrough 2010: p. 361).

Under this scenario of limited evidence and incentives, the private sector's role in adaptation processes would need to be significant, with firms themselves providing the services to understand climate risks, technology and business models needed to make climate resilient investments (Biagnini and Miller 2013). A lesson can be drawn from disaster risk reduction, where the business model approach pursues the integration and alignment of disaster risk reduction with the existing operational and strategic goals of an enterprise (Warhurst 2006; Roeth 2009).

The involvement of the private sector might vary depending on the size of the firm, ranging from micro and small enterprises where the basic integration of adaptation planning will be driven by awareness and understanding of local climate and disaster risk, to medium and large enterprises were more strategic forms of adaptation might include financial mechanisms to protect labour force such as providing employees access to insurance services, enhancing supply chain resilience or coordinating disaster risk reduction or adaptation measures with local stakeholders, drawing information from participating in research partnerships or developing new business models that account for the increasing variability of production costs and losses derived from higher levels of climate risk and impacts.

2.6.4 Business Model innovation

> "*Innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption.*" *Rogers (1962: p.11)*

The previous sections describe the types of contributions that firms could make to adaptation. These could take the form of different actions, including the introduction of new technologies; changes to operational processes or strategic planning to develop adaptive capabilities; and engagement through the different mechanisms of CSR, partnerships or business models. This thesis focuses on business models, and this section presents the various elements of business models that connect experimentation and innovation with the integration of climate change adaptation into firm business models.

A significant number of scholars focus on business model innovation as a vehicle for corporate transformation and renewal (Zott 2011; Demil and Lecocq 2010; Ireland et. al. 2001; Johnson et al. 2008; Sosna et al. 2010; Bouchikhi and Kimberly 2003; and Chesbrough 2010). According to Teece (2010: p. 178), new business models themselves can represent a form of innovation. Some of the adaptation projects of individual firms studied in this thesis represent the segment of early adopters that have incorporated climate adaptation actions into some aspects of their business operations and model.

Individual firms have demonstrated their capability to incorporate sustainability into core business functions by integrating related practices into corporate functions such as quality control, strategy development or health and safety (Hall and Wagner 2011: p.183). Sustainability thus becomes a de-facto objective in a variety of business routines, which assists in the consideration of mechanisms for integration sustainable approaches across the firm.

The integration of sustainability principles into functional areas within a firm can go unobserved by employees or stakeholders but can still guide or shape the firm's economic and environmental performance (Hall and Wagner 2011: p. 185). This is known as modularisation (ibid: p.187), where information or new practices remain in silos across the organisation but still influence its activities. Modularisation processes are relevant to understanding adaptive actions that might be observed in operational modules or protocols in the firm yet remain compartmentalised within specific departments.

For example, new technologies to monitor moisture in agriculture or climate forecasts might be used to determine transportation schedules but remain isolated in the area where these decisions are made, without being vertically integrated into strategic decisions or communicated to other departments that might also benefit from this information. Integrating sustainable development consideration into business models requires the integration of environmental management with general management, yet in most cases these are separate systems with only minimal links in terms of personnel or organisational structures and processes (Hamschmidt and Dyllick 2001: p. 187).

According to Afuah (1998) and Afuah and Bahram (1995), innovation should be viewed from the perspective of a wider social network of suppliers, customers and complementary innovators. The capacity for conversion of external knowledge into innovation is derived from the firm's ability to explore, assimilate and transform external knowledge (Camison and Fores 2010, Lane et al. 2006, Lichtenthaler 2009) and to incorporate it into routines embedded in the business model. This strategic innovation can reshape the existing model (Christensen et al. 2002) and enhance the dynamic capabilities of the firm by responding to changes in the business environment (Gebaur et al. 2012).

The firm's ability to absorb new information is shaped by routines that can identify and acquire knowledge about the environment and changing external parameters, which include routines to analyse, process, interpret and understand this new knowledge in accordance with internal structures (Shimitt and Klarner 2014). These authors establish that routines that alter the existing knowledge structures of the firm and lead to the identification of strategic opportunities can be considered transformative, and highlight the value derived from the successful application of new knowledge within firm operations.

These adjustments to firm routines allow the firm to refine its business model and adapt to a changing external environment (Camison & Fores 2010; Easterby-Smith et al. 2008; Lane et al. 2006). This points to a capacity to recognise and utilise information to deploy adaptation actions, which results in increased likelihood of drawing economic value from these actions.

2.7 Diffusion of Innovations

The function of individual firms in mobilising information and knowledge has been described in the literature. Less emphasis has been placed on the potential to halt or limit diffusion of innovations, information, knowledge or resources in locations under climate stress. The diffusion of innovations is the dissemination of abstract ideas, concepts, technical information or actual practices within a social system, where the process of diffusion flows from source to adopter, either via direct communication and influence (Rogers 1995), and the information can be adopted (or rejected) by members of the social system (Nutney and Davies 2010 citing Rogers 1995).

The ways in which an innovation is diffused from a source to an adopter will differ according to the innovation's consequences (Wejnert 2002). In the case of diffusion of climate adaptation actions among business firms, a core tension exists between the public versus private consequences of an innovation (Wejner 2002: p. 299 citing Feder and Umali 1993; Meyer and Rowan 1977; Strang and Meyer 1993). These consequences refer to the impact of the adoption of the innovation on entities other than the firm (public consequence) versus the firm itself (private). A differentiation has been made by conceptually deriving the levels of consequences outlined in the previous sections between: 1) private sector adaptation, and 2) private sector contributions to adaptation. Were the former is focused on organizational change and developing capabilities to respond to increasing climate impacts, and the latter is conceived as contributions to social processes of adaptation, both directly to through supporting various dimensions of adaptive capacities of individuals, groups or communities, or indirectly by deploying resources that might not accrue direct benefits to the firm but might be diffused in time and space to indirect or undetermined beneficiaries.

These las forms of contributions can be considered a form of public consequence innovations, which are adopted when information and imitative models are uniformly distributed around the world, and throughout practices and values deeply ingrained in society, reflecting a shared understanding of reality (Meyer and Rowan 1977: p. 343). The interactions between international and local actors can greatly influence how signalling, practice and communications occur in the dissemination of innovations with public consequences. In this process, international organisations are central to the diffusion of information and new models among businesses.

The research on innovation in organisations points to two different research agendas (Wolfe 1994): research on the diffusion processes, which studies the pattern of diffusion of an innovation with early adopters, followers and laggards (Rogers 1993); and research on organisational innovativeness, which studies the determinants of a specific organisation's propensity to innovate (Nutney and Davies 2010).

Diffusion of innovations under climate change "unilaterally has looked at adoption side, but the promotion side needs to be studied as well" (Mikl-Horke 2004: p. 109). This points to the importance of international organisations, universities, local research organisations and governments as knowledge brokers and diffusers of information that signal firms to mobilise resources for innovation, but also to the importance of firms themselves in relaying information pertinent to climate adaptation. Characteristics of the adopter, including organisational strategy, structure, resources and politics, influence the rate of adoption (Mikl-Horke 2004 citing Dean 1987, Dyer and Page 1988; Schroeder et al. 1989), their position in a social networks and trends in adoption (Abrahamson 1991; 1996). Another factor influencing private sector adoption of climate adaptation innovations is low environmental uncertainty or perceived stability of environmental conditions, which makes organisations reluctant to change (Mikl-Horke 2004 citing O'Neill et al. 1998). This is particularly true in economic sectors that do not immediately perceive any impacts of climate change, such as industrial or technology firms, where operations are not directly tied to environmental changes in the same manner as agriculture or food systems.

Finally, diffusion may be facilitated by a firm's need to achieve legitimacy (DiMaggio and Powell 1993) in a supply chain, to create a sense of security, stability or generate trust among shareholders or associates. This can also prompt imitation from larger and smaller firms in a supply chain. The adoption of sustainable practices or green-washing activities. Greenwashing is "*the selective disclosure of positive information without full disclosure of negative information so as to create an overly positive corporate image*" (Lyon & Maxwell 2011). This includes exhibiting symbolic compliance to environmental regulations or consumer demands (Marquis et al. 2015) or misleading consumers about the firm's environmental performance or benefits of a product or service delivered by the company (Delmas and Burbano 2011). This corporate behaviour tends to create the illusion of accountability or commitment by the company to environmental values. For example, selling food or beverages reported as sourced sustainably, or exaggerating the water used or recycled in production. Often these mechanisms have been part of the self-regulating regime that drives corporate social responsibility agenda, the self-imposed monitoring to maintain or create corporate value.

2.7.1 Early adopters and prime movers

According to Rogers' (1995) classification of innovator organisations, there are different levels of early adopters. Early adopters are ready to undertake innovation when benefits begin to be observable, giving them a competitive edge over others. The early and late majority follow once the innovation has proven cost-effective and low risk. While early adopters are willing to undertake risks, invest and experiment to develop innovations, early and late majority will not make direct investments.

The laggards will be the last to adopt innovations. They consider changes as high risk and will only incorporate innovation based on proven practice and set industry standards. The characteristics of the innovation's promoters can influence the extent and velocity of adoption, including factors such as contact between an agent of change and the adopter (Rogers et al. 1970), credibility (Coleman et al. 1966), and the role of influential opinion leaders like politicians, academics, business leaders and journalists (Rogers 1983; Kautz and Larsen 2000).

A study by Jacobson and Johnson (2000) on the diffusion of mitigation innovations in the energy sector found that the importance of prime movers is fundamental to raising awareness, prompting others to undertake investments, providing legitimacy to innovations and diffusing new technologies. In the case of technology, adoption is appealing due to the potential to lower costs, improve efficiency and provide reputational benefits for the adopting company. These benefits translate into increased shareholder value and operational profitability. The case of climate mitigation in the German wind turbine industry provides an example, as prime movers played an important role in diffusing the mitigation innovation by transforming an energy system into one based on renewable energy (see Mikler 2010). However, firms must be prepared to overcome the so called 'valley of death', metaphor to describe the lack of resources and expertise in developing or implementing an innovation (Markham et al. 2010), but also several challenges in the innovation process, which include behaviour and mindsets of those driving the innovation, managing resources, testing and working with the key people to transfer an idea to a workable prototype, process or mechanism (Herbert 2016).

The impact of the adoption of new technologies that increase energy efficiency and reduce CO_2 emissions can be more readily measured or quantified that adaptation measures, as direct investments in clean technology or carbon trading schemes and their adopters of these measures can be more easily mapped and identified. This is not the case for adopters of adaptation measures, as firms might not recognise adaptation-related activities, fail to find value in documenting and disseminating these actions or be unwilling to disclose measures to avoid creating the perception of undertaking investments that do not generate direct or immediate benefits for the firm.

For these reasons, examples of prime movers in climate adaptation from the private sector cannot be easily identified. To begin to map out characteristics and profiles of prime movers in the private sector, it might be particularly important to consider diffusion based on geographical location and proximity to hazard (Meade and Islam 2006, citing Goldenberg et al. 2000); for instance, considering economic clusters where firms are dedicated to the same economic activity in each location, such as wine- or coffee-producing regions, or in locations where extreme events are common and faced by all local firms. Innovation processes are then "rooted in context-specific, core competencies and knowledge bases" (Mueller and Zenker 2001: p. 2). This points to the importance of regional approaches in private sector contributions to adaptation, business model innovations and knowledge sources. Each has been considered in selecting case studies for this research.

2.8 Pathways for Adaptation Actions

The relational view of the firm allows for the identification of pathways for communications and resource exchanges between the firm and external actors. These exchanges can create tensions between formal, deliberate participation and forced participation among different actors of a production system, where relationality can be determined by a dominant model of pre-set relationships based on fixed economic drivers and calculations. This is particularly true in the business model approach to understanding adaptation processes, where the firm can extend its influence to occupy relational spaces by deciding on adaptive options for different actors facing climate stress. The pathways of communication and resource exchanges are part of what economic geography calls the firm coalition or firm transaction network. Pelling et al. (2005) describe two forms of networked relationship that inform these negotiations: canonical pathways that include formal institutional relationships, contracts, partnerships and consortiums; and shadow systems made up of informal communications, personal relationships and cultural norms.

The formal or canonical spaces are visible and subject to rational control and management through public and institutional frameworks, whereas informal or shadow systems are informed by tacit institutions, including intangible ones such as cultural norms, values and accepted ways of doing things (Pelling 2010). Each system can capture potential flows of information and resources across a system and be used to describe the interactions across the relational space between a focal firm and its associates and external stakeholders. While these pathways have been used as a framework to understand organisational learning processes, they also provide insight into the actions identified in the preceding sections, such as exchanges of information, deployment of new technologies, investments in infrastructure or coordination activities among associates. Canonical and shadow system pathways of interaction can be understood as spaces where exchanges of resources take place and knowledge is mobilised, contributing to adaptive capacity of organizations and communities. These pathways are central to identifying exchanges of resources and information within organisations, as well as those that take place indirectly, including between the firm and individual households or between a local government and the firm. These exchanges will inform the firm's place and degree of control within the underlying relationship. In some instances, it might be that shadow systems are not amenable to firm control but are essential to produce adaptation co-benefits between the firm and its host community or supply chain.

Individual firms can also redistribute important value along these pathways by drawing information and resources from one source and redeploying it through another pathway in the form of expertise or material resources to improve local regulation of climate risks or disaster. This conceptualisation of the firm and local adaptive processes requires an understanding of the role and functions of individual firms in co-generating adaptive capacities or limiting adaptive options by employing firm-centric approaches to adaptation needs.

2.9 The firm in economic geography

The firm is an economic agent in a dynamic relationship with different elements of a production system. Walker (1989) provided a revision of early corporate geography that focused on studying firms separately from capitalist development processes. Early work on firms was classified as 'geography of enterprise' (idem. p. 43), which used spatial perspectives to examine labour, the geographic importance of plant locations and the expansion of economic activities. These studies were subordinate to broader framings of industrial geography, which placed importance on the forms of industrial organisation and spatial configurations of industrial production (Dicken 1986; Townroe 1975; Gilmour 1974).

The changing economic landscape and transition into globalised economic processes drove corporate geography to move beyond studying the single-plant small firm, as this proved insufficient to explain emerging multinational corporations and complex industrial clusters. This thesis intends to revisit the spatial perspective on individual firms motivated by the recognition that adaptation is a local process and analysis must be firmly placed on a firm's social and economic linkages in local geographies. Firms are central actors in capitalist economies and the foundation of regional economic processes, they are necessary to understanding macro-geographical transformations (Dixon 2010). According to Schoenberger (2000) the changes in firms are not solely the function of prices, products and markets but, more importantly, of the ability to manage space and time: "*What kind of change, who will fight for it and who will resist depends on historical and geographical conditions*" (Schoenberger 2000: p. 300). This is a crucial component of understanding firm decisions and drivers to develop adaptation spaces that align with their economic values and views.

Taylor and Asheim (2001) propose that the firm is a "phenotype": a site where different elements provide structure to the firm, but also react to external conditions. The authors argue that economic and social processes intersect, yet the firm remains viewed as separate from the spatial scales of the economic system and from the locations that characterise its activities. Individual firms represent capitalist forms of expression that behave in accordance with permissible institutions, regulations and norms. There activities can be organised in different ways, leading to a variety of economic trajectories. These result from the strategic behaviour of individual firms embedded in different institutional environments (Peck and Theodore 2012). The activities of firms are driven by the search for a strategic fit in the market, and are shaped by the norms, policies and regulations in place where they operate. Firms operate in different institutional environments. The varieties of capitalism approach proposed by Hall and Soskice (2003) identifies two competing capitalist value systems, expressed through differences in the organisation, trajectory regimes and business models of the firm.

The first is the socially-coordinated 'Rhinish' model of Europe and Japan, which is described as more egalitarian and having higher levels of social distribution. Firms are viewed as communities and group interests take precedence over individual interests (Peck and Theodore 2010). The second is the classically neoliberal model of

Anglo-American countries (Albert 1991), where competition and market forces are paramount to understanding corporate behaviour. Firms embedded in these different systems respond differently to threats and pressures from various stimuli (Burke 2008).

The realisation that firms behave according to a possible spectrum of values and structures has important implications for firms' functioning in regard to climate change response measures. Their involvement in socially-coordinated strategies will vary greatly according to their location, institutional setting and value system. The importance of individual firms' values in climate change engagements was illustrated by Mikler's (2012) varieties of capitalism debate, which drew on the example of Germany's technological innovation to transition to sustainable energy for climate change mitigation projects. During this project, firms coordinated with governments and competitor firms to transition to green technologies.

This provided a nuanced view of how firms' behaviour and coordinated functioning can be shaped by different institutional, cultural and operational values. The importance of context has also been emphasised by Soskice (1999), who argues that individual firms in coordinated economies will seek to set standards based on consensus, have close relations with business associations and research or academic institutions, mitigate competition in internal markets and seek regulation of relational contracting. These have all been identified in adaptation literature as critical for developing adaptive capacities.

Economic geography has engaged with these ideas, proposing that such cultural perspectives underplay the richer, dynamic influences of place and space, and uncouple the importance of specific locations in shaping the firm's operations (Taylor and Asheim 2001). Geographers have conceived of the firm in relational terms as an organisation requiring key competencies and capabilities to manage upstream and downstream inter-firm relationships, with implications for innovation and diffusion (Bathelt and Glucker 2005) and, therefore, for adaptation.

A recent paper in geographic thinking sought to "destabilise the entrepreneurial thesis" (North 2016: p.450) by presenting an argument that challenges formalist views of economic decision-making based solely on profit seeking behaviour. This introduced considerations of the function of the firm shaped by a relational perspective, including cultural and social dimensions. This view challenges more established, firm-centric views and widens the scope of analysis of adaptation processes.

In understanding adaptation processes of economic assemblages, it will be critical to think beyond the vertical supply chain discourse of "bottom-up" and "top-down" and include a horizontal discourse of "inside-out" and "outside-in" (Wendt 2010). Looking at inside-out and outside-in flows of information, resources and stimuli can be conceptualised as looking at the business model to describe the internal elements of the firm and expanding the boundary of a firm's sphere of influence towards external linkages. This relational view of the firm recognises that firms are embedded in communities and will respond to threats from the spatially-embedded structures of organisation. This relational element places analytical relevance on the position of the firm with respect to a variety of external actors. The relationship between the firm and the local context is central to understanding the changes that firm's functions might undergo in response to climate change risk and impacts.

The magnitude of expected climate impacts will challenge the firm by altering the normal parameters under which its behaviour and social purpose is understood. Therefore, building on the theories of innovation of business models (explained later in section 2.11), a re-conceptualisation of firm drivers and functions is permissible when exploring climate change adaptation processes, with the firm at the centre of a coalition or a transactional network.

These coalitions or transactional networks include different members or actions, such as managers, employees, shareholders, suppliers, customers, regulatory agencies or professionals (Cyert and March 1963: p. 27). The relationship to these different local actors is expanded upon in Chapter III through discussion of different spatially fixed patterns through which information and resources are exchanged, and the firm can deliver or draw value that can be used to develop adaptive capacities.

2.10 Assemblage theory

Assemblage theory was first proposed by Deleuze and Gauttari (1987). These authors propose that assemblages are made of different components, formations of things and places, and define them as:

> "*strata and territories; but also, lines of flight, movements of deterritorialisation and destratification with different rates of flows along lines [or connections that] produce phenomena of relative slowness, or, on the contrary, of acceleration and rupture. All this, lines and measurable speeds, constitutes an assemblage*" (Deleuze and Gauttari 1987: p. 4).

This definition points to location and connections that produce or disrupt events at different speeds, where in the assemblage, actors, objects, flows of information and resources organise and move arrangements in a specific site. The combination of these different elements and qualities is relevant to understanding adaptation responses and processes, as stakeholders will have a changing variety of relationships and resources according to the space and time at which climate change is experienced.

It is the emergent properties of the whole, which provide a new framing to understand social entities (Delanda 2016). The influence and configuration of these assemblages' might change through shifts in how the various components interact, without a specific boundary facilitating or subverting adaptive options for the members of the assemblage, whether individuals, groups or organisations.

This view of spatiality refers to different components mobilised and formed through a combination of elements, which can be re-arranged into new formations without defined boundaries. It is a dynamic and open process of change. Anderson et al. (2012) think of agency in distributed forms and causality as non-linear, where assembled orders can be stabilised and changed, pointing to the tension between stability and transformation in the production of the social order. In assemblage theory, places are in motion and only temporarily static (Anderson 2012). Thinking relationally, spaces are “open-ended, mobile, networked and actor-centred geographic becoming” (Jones 2009: p. 5). This thesis is centred on firms but expands to examine the changing relationships and movements within specific spaces that influence adaptation responses and capacities.

Jessop et al. (2008) similarly frame socio-spatial relationships. These authors identify four dimensions: territory, place, scale and network. These dimensions, associated with socio-spatial structuration, produce various orderings of the social, including processes of accumulation, hegemony and power. Different entities, including actors and things, can acquire form and movement in accordance with their relative position in a relational configuration (Anderson et al. 2012). This means that potential to move towards desirable places or functions is related to their capacity in comparison to other components linked to the same place.

Assemblage theory proposes the formation and ordering of different assemblies of things, including smaller formations within a broader configuration, which can undergo an “ongoing process of arranging and organizing emerging from flows, connections and relationality between bodies according to their capacity” (Kennedy et al. 2013). The authors discuss a tension between stable and unstable elements, where the questions are “not about what assemblages are, but what they do” (idem: p. 49). The analysis of assemblages requires examination of the different components and style of structuration (Bennet, 2012) to understand the social formations and changes in the grouping of institutions, actors and practices.

In the context of climate change adaptation, notions of ordering and agency include capacities shaped by information, technology and resources that might drive specific formations in response to climate stimuli. The analysis focuses on what an event allows bodies or things to do (Dewsbury 2011: p. 148), and examines what "events break, interrupt or change in the relationships" within an assemblage, which may lead to new relationships (Anderson and Harrison 2010: p. 15), behaviours, outcomes and capacities critical for shaping or determining adaptation trajectories.

The function and power of actors' actions in mobilising assemblages or challenging different formations as they contest authority arguably presents an open view of the social and economic interactions in adaptation processes. The assemblages involving firms are not guided by social relationships, but by economic relationships that influence the emergent properties of the different formations, where each component, piece of information, technology or practice has embedded economic calculations.

Furthermore, determining velocity in the assembly of emerging formations, or formation speed, informs the examination of the different articulations of adaptation responses of a variety of individuals, groups and organisations in specific locations, where smaller and different assemblies might be driven by different motivations than those of the firm. The application of assemblage theory to adaptation will be tested by empirical focus on the assembly of spatial forms and processes, how these can be maintained and degrees of internal tensions (Anderson 2012).

These tensions and changes provide analytical elements to understand change, learning and innovation that contest or align adaptive responses to climate or disaster risks to social forms of adaptation. Assemblage theory allows for the identification and description of components, then then the examination of the specificity of each component to unpack the underlying information and relational elements. This provides insight into the transformation of relationships between different actors, things and spaces under changing climate patterns.

The assemblage theory proposes that assemblies can be mapped by identifying the encounters and forces shaping the formations (Anderson et al. 2012 citing Anderson and Harrison 2010; Bennet, 2005; McFarlane, 2011; Saldanha, 2007; Sawnton, 2010). This points towards methods that can identify both the components of the assembly and the behaviour of the different actors that comprise a set of relationships or configuration. In assemblages, relational approaches view inclusion, internal composition and force in terms of elements that are interrelated (Saldanha 2012). The internal components of those interrelated actors, things and technologies make up an assembly, connected at different points, while others might extend towards different assemblages. These ideas highlight the importance of examining the internal components of the business model assembly, where stability or change will depend on the driving force that prevails in resolving the internal tensions, which define the connections towards external components or elements interconnected to the firm.

The tensions and prevailing logics guiding the formation of production assemblages under climate stress open an analytical space to examine the functions of the firm, the role of innovations, the limits and flows of information and different elements mobilised by a firm to understand shifting patterns of adaptation. The assemblies of different entities or actors with various levels of capacities vie for the ability to decide upon their desired adaptation trajectory.

While assemblage theory proposes that these have no defined boundary, in the context of individual firms, the configuration of the business model and the resources and actors that are identifiable in their supply chains provide an imaginary outline of the firm's influence over a specific site. Within this space, an economic assemblage is created where land, technology, members, information and resources have a purpose, but smaller assemblies and connections that expand the boundary towards different sites and actors provide avenues to introduce or extract elements. This results in the constant reshaping of the form of the economic assemblage. In the context of a changing climate, these movements determine the ability to adapt and the trajectory of such actions at a specific time.

The assemblage literature highlights the components, velocity and force of the formation of assemblies, but does not draw attention to the hierarchy and sequence of the assemblages or formations. This is a gap in the literature and central analytical feature in this thesis, when different adaptation outcomes of the assemblages might have different sequences and hierarchies of economic, technological and financial components ordering and shaping actor's ability to cope in locations under climate stress.

Research Gaps and Hypothesis

This thesis' main contribution is to advance the concept of the business model by combining and introducing the literature on climate change adaptation, and further introducing approaches to understand firm behaviour from economic geography. There is a gap in academic literature on climate adaptation that examines the social function of individual firms embedded in communities under climatic stress, where a broader temporal and spatial view of adaptation is required (Burton 2015; Shearer et al. 2015; Kuruppu 2013; Pauw and Pegels 2013) and the processes and mechanisms of adaptation linked to co-production and innovation in the private sector and the barriers to information and knowledge sharing of climate relevant knowledge by individual firms to better understand the distributional consequences and opportunities of climate responses of small, medium and large enterprises at local levels.

The diverse economies approach informed the relational view of the firm and the short term-long term trade-offs firms might be able to accept to coordinate their economic activities, with the objectives and aims of the public good represented by the State. However, the approach requires a broader link to policy regimes and institutional systems which might be absent in the developing economies of the global south. While introducing the linkage of climate change adaptation processes to the different forms of economic behaviour, and the changing role of the firm in different economic context, the framework would have been easily transferable to understand the relationships of firms in local communities. Making the first connection to view developing regions differentiated forms of economic relationships under climate stress will be a preliminary step in theory building work on adaptation in the developing world.

Therefore, assemblage theory provided a framework that was applicable to the local context, where a discrete relationship between actors, processes and materials could be examined under a changing climate. The assemblage theory can conceptualise the business model and the firm as an assemble within itself, but also provided the framing to expand the analysis beyond the single organisation towards a series of undefined number of actors, occupying a space and allowed to understand adaptation as an outcome, where the adaptive actions and changes in a first assemblage, could be observed as they changed and a new one emerges, with changed relationships and characteristics. This framing provided the elements to view adaptation as a dynamic process occurring among a set of actors, bounded by social or economic ties, but permeable to allow for information, resources and knowledge to be exchanged beyond a defined boundary. This was a basis to understand adaptation in a context of local relationships imbedded in economic processes under climate stress.

The thesis then focuses on both the firm's business models and the relationships to view actions as parts of adaptation, and their effect over actors and spaces where the firm has social, economic or political influence. The hypothesis of the thesis is that sequences of business routines and actions enacted or deployed in response to climate impacts will reconfigure the relationships of the firm and shape adaptation trajectories that often might not be immediately perceived.

These business routines and actions can be interpreted as “adaptation ripples” or means- to-end chains which are the effects that any single adjustment in the business model in response to climate stimuli can have on other actors’ adaptive capacities or adaptation options. This suggests that actions deployed in one place or for the benefit of specific actors might have an impact and prompt change in locations or activities removed from the initial intent of the firm. If we can understand the consequences of strategic or unplanned business actions upon communities in the context of adaptation, it may be possible to conceptualise business models that recognise and integrate inclusive and equitable local innovations.

A second hypothesis is that business models can enhance adaptation by leveraging the core capabilities of individual firms. The recent policy literature makes references to business models as forms of engagement of the private sector in adaptation, after corporate social responsibility and partnerships. This inclusion is made on the assumption that business models provide a deliberate and strategic approach for individual firms to invest in adaptation, this assumption will be the basis of the research design for the fieldwork and empirical work of the PhD.

Conclusion

The role of the private sector in building adaptive capacity has only begun to be understood, and theoretical perspectives are needed to understand how the functions of firms can incorporate and cope with climate and disaster risk. The firm is a social construct that enacts the dominant view of capital accumulation, distribution and value, which will be challenged in the future by resource-constrained and climate-vulnerable communities.

Theorising on the function of firms under a climate uncertain future requires the incorporation of key features of time, place and space to propose accurate conceptualisations of adaptation processes and explore the role economic agents play in shaping human or natural systems as they adapt to climate stress. The different local assemblages, in which shifting social and economic relationships might change in response to increasing climate impacts, could follow alternate trajectories depending on the broader institutional setting.

Different forms of economic and capitalist drivers can shape the functions of a firm or align its role to broader development and adaptation processes. Firms will behave differently if placed within a variegated capitalism perspective; accepting different functions, seeking and sharing information differently and allowing different short- to long-term trade-offs to protect against the climate externalities faced by small suppliers, employers or community members through adaptation. This is at the core of the potentially different paths that local assemblages might experience in the context of accelerated climate change impacts.

A firm's operational imperative requires the creation, extraction and delivery of value to increase profit, and innovation in the context of climate change adaptation would result in what could be called "climate-integrated business models", where firms would recognise the importance of and incorporate into their operations adaptation actions that reconcile business objectives with social contributions to adaptation, seeking to develop both internal and external adaptive capacity to maintain or enhance economic or social security, advance development and create local resilience. The established drivers of business behaviour will likely be less viable under climate change and firm functions will need to be reconstructed if developmental gains are to be maintained in the future.

1. The primary aim of this doctoral research is to analyse the functions and actions of firms in the context of climate change adaptation. This is possible by identifying and understanding emerging business actions in response to

perceived or real climate change impacts and mapping the shifts that business configurations undergo to manage these impacts.

2. A second objective is to analyse the interactions between business configurations and local associates and stakeholders in shaping adaptive capacity. This is informed by relational thinking in economic geography, and proposed pathways of information and resources exchanges among different social actors.
3. Finally, the thesis aims to explore how current business configurations under climate stress influence adaptation responses and examine the challenges in integrating and diffusing adaptation innovations among local suppliers, employees, households and communities. The thesis presents evidence from observable adaptive behaviour on private sector responses to climate and disaster risks.

This chapter provided a conceptual framework differentiates between private sector adaptation and private sector contributions to adaptation. This is important to examine organisational responses and changes, and the influence these responses on external individuals, groups, organisations or institutions. This second view shifts the analysis from the focal firm to a broader stakeholder community, containing multiple connected and interdependent agents in each site of operations. The recognition of interdependence as a resource for adaptation can and may lead to new relationships between actors and organisations that go beyond fixed assumptions about relationships that are based on competition (businesses and supply-chains), antagonism (labour unions) or regulation (government), causing changes in business models in climate-sensitive sectors.

The impacts of climatic extremes are gradually shaping firm configurations by prompting incremental adjustments to their business routines and relationships to maintain stability, which presents new challenges to established business models. Climate change adaptation has been recognised as a local process, and individual firms are embedded in the social and economic life of communities. The different mechanisms for leveraging resources from firms for disaster risk reduction and sustainable development, such as partnerships and corporate social responsibility, have limited capacity to provide long-term adaptation impacts.

The analysis of business models provides an entry point to understanding firms' alignment with adaptation needs, but this perspective has largely remained unexamined in the context of climate change, which presents an opportunity to analyse models as the representation of dominant capitalist arrangements driving individual firms' behaviour. A novel conceptualisation of business models can provide information on how firms recognise and incorporate adaptive actions into their operational model and look at the link to different dimensions of the firms and local actor's adaptive capacity, created or eroded through their resource supply-chains, which includes influence on workers and host communities, governments or other business sector actors.

The adjustments to business routines can lead to reconfigurations of relationships, which demands that the boundaries of firms' business models expand to a relational view of the organisation. The PhD framework seeks to expand the boundary of analysis beyond an organisational study to examine the social function of the firm in the production of adaptation spaces, and the capacity of economic agency to influence adaptation options and adaptive capacities of individuals, groups or communities at the local scales. The adaptation actions of individual firms embedded in business routines can influence adaptive capabilities through exchanges of resources and information along formal and informal pathways to a variety of stakeholders. The linkage of adaptive actions to specific beneficiaries provides analytical depth to the study of adaptive capacity at different points in a system, with a dominant economic agent at the centre. While stakeholder theory provides a basis to identify the variety of agents connected to or nested in the firms' activity, economic geography widens the analytical space to a relational view of firms. This can be further abstracted to understand adaptive processes, resources, innovations and exchanges in different spatially-distributed assemblages.

CHAPTER III

Methodology

Introduction

Different kinds of adaptive actions emerge from business routines. Either through unintended or deliberate actions in response to climate change, which contribute to adaptation. This chapter describes the methodology used to map and characterise actions that contributed to adaptation, and the framework to establish a link to business model components and adaptive capacities of multiple actors in socio-economic assemblages. The first stage of the research design focused on the types of adaptation responses reported by the private sector in a global context. The data was used to select field locations by identifying the characteristics of and rationale for selecting research participants to map changes in business routines of firms under climate stress. The final stage, was focused on the analysis of the changes in different assemblages, to explain actions contributing to adaptation, and their role in the reconfiguration of relationships shaping adaptation trajectories of a variety of actors in distinct locations and levels of exposure to climate risk.

3.1 The Research Unit

The research unit was conceptualised on the basis of the preceding literature discussion. The research design begun with a firm-centred approach with the firm as the primary unit of analysis for the thesis. The analysis extended outwards by mapping the firms' relationships into what constituted the social and economic assemblage in different geographic locations. The methodology was designed to pinpoint incremental changes and disruptions to business routines and relationships from climate related stressors, which resulted in actions to manage impacts. The study looked at the primary relationships of the firm – those necessary for the organisation to function – which provided evidence of the firm's embeddedness in the social and economic life of host communities through their employees, suppliers and/or other local actors. These actors are linked to the firm through an array of formal and informal (or shadow) pathways, where resources and knowledge are created, lost or negotiated under the increasing pressures from climate change impacts and extreme climate events.

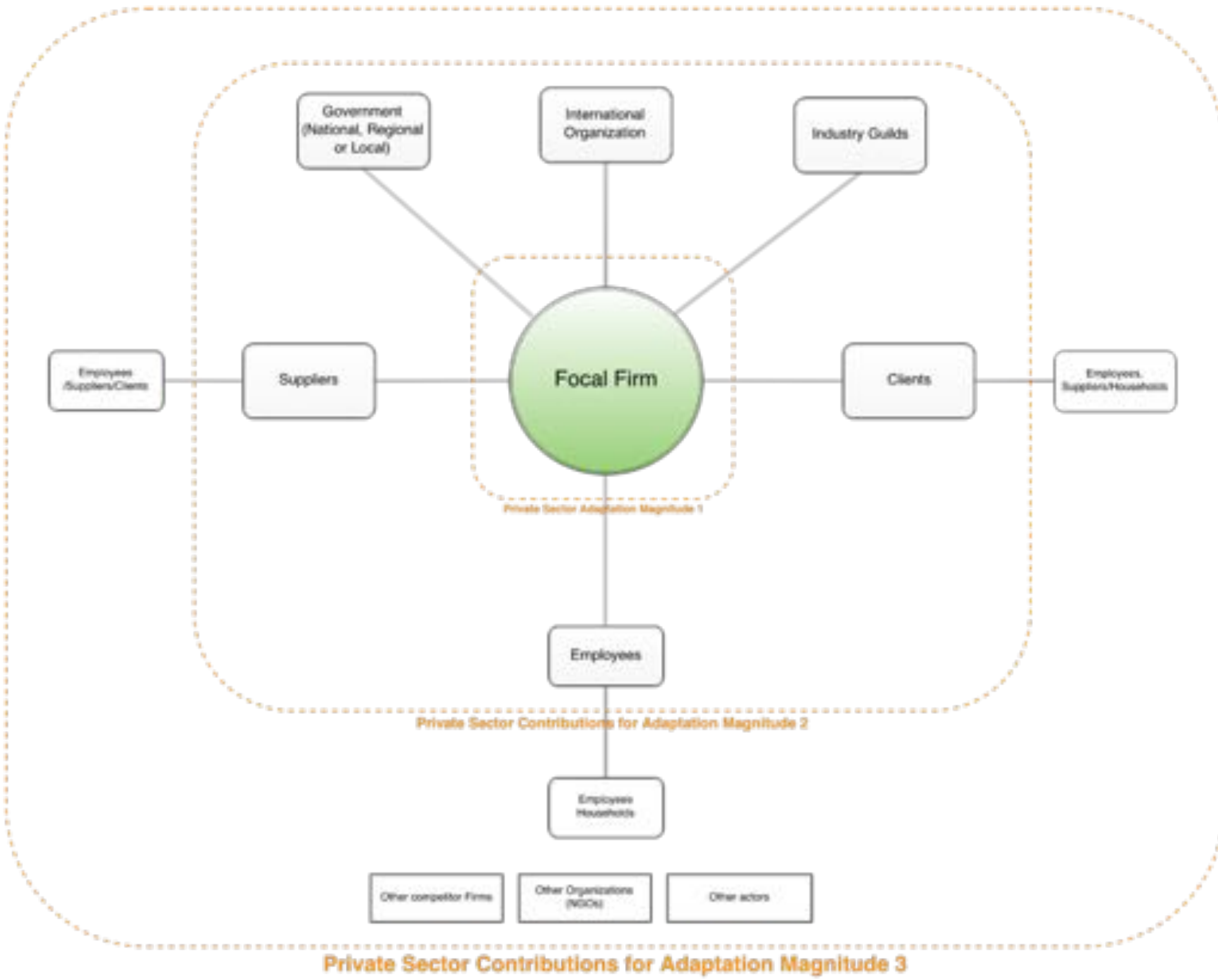
The conceptual boundary for the research was determined by the focal firms' business models, which was described by the firm's officers themselves by identifying locations where financial value was deployed or extracted to perform the firm's functions. Within the boundary of the business model, different components and members of assemblages were observed and interviewed, to map the flows of information and resources, contributing to adaptive capacities, between the firm and external agents such as farmers, cooperatives, research institutions, agricultural colleges, technology suppliers or local governments.

This array of actors determined the boundary and components of the business model, and the pathways or relationships where the firms performed business routines. The data was collected through a series of observations, semi-structured interviews, secondary reports and information, and participatory meetings with company officers.

A methodological choice was made to limit the scope of the research and create a boundary by focusing on key senior planners, mid-level managers and field operators to establish and map the firm's current relationships, and the selecting external actors for sample interviews. This included suppliers, participants in experimental pilot projects, research organisations, institutions, guilds and local government offices.

The figure 5 below illustrates a preliminary set of direct relationships of a focal firm, through which resources and information for adaptation can be gained, deployed or extracted. The model initially considered six relationships: 1) firm and suppliers (associates); 2) firm and government; 3) firm and knowledge organisations; 4) firm and business associations or guilds; 5) firm and clients; and 6) firm and employees. These external actors are linked to components of the firm's business model. This does not mean engagement with the firm as an anonymous entity, but with specific internal agents or departments, where actions can be traced by identifying the daily business routines and exchanges between individuals or department groups in the organisation to external individuals, groups or organisations.

Figure 5 Firms Relational Pathways-Assemblage



The conceptual model is firm-centric. The aim was to test the validity of a relational approach between the firm and its direct associates. The research questions explored a range of relationships that influenced firm behaviour. In addition to those mentioned above, the model considers: (1) internal relationships, or how relationships between employees or departments interact with other adaptation components within the firm; and (2) relationships between actors, or how relationships with clients or government might impact firm- or individual-level adaptation pathways.

The research methods discussed below build on the approach described here to identify the negotiated quality of firm-centred adaptation and, through this, to begin a study of the boundaries of the firm's business model under climate change. This has implications for the understanding of and support for adaptive capacities as part of wider social processes (Pelling 2011). The research design was developed on the assumption that disruption of business routines by climate or disaster impacts (including through market, technology or regulatory signals) would be observed along the relational pathways, and the adaptive responses to normalise these routines could be identified, independently if the firm recognised their actions as adaptation or just as responses to emerging problems in their supply chain or internal organisational routines. The methodology aimed to identify shifts by framing them as contributions to adaptation, as well as their drivers and outcomes.

3.2 Methodology

The data collection, management and analysis techniques employed for secondary and primary data were designed in a sequence to build on the results of the previous stage.

3.2.1 Secondary Data Analysis

The first question proposed by the thesis is: *What are the types of emerging climate adaptation actions amongst private sector firms?* This required an analysis of reported adaptation projects by individual firms across various economic sectors at the global scale. The aim of this analysis was to identify, characterise and connect adaptation actions to actors including the firm, and provide a conceptual map of activities to establish the relationships between the firms' adaptation actions, components of its business models and socio-economic assemblages in their host communities.

After the 2011 launch of the Adaptation Programme of the UNFCCC Secretariat under its Nairobi Work Programme (NWP) on impacts, vulnerabilities and adaptation to climate change, private sector companies were called upon to submit case studies to showcase innovative approaches to adaptation. These case studies are archived in a searchable platform, with the stated aim of catalysing the involvement and engagement of the private sector in the broad community of actors working on adaptation. This database can be accessed through the following link: http://unfccc.int/adaptation/workstreams/nairobi_work_programme/items/6547.php

The platform contained 100 self-reported climate adaptation projects at the time of research (October-December 2015). The earliest documented case dates to May 2013. The case studies include detailed descriptions of how firms have deployed resources to adapt to climate change, reduce business risk, decrease impacts of extreme climate events and seize opportunities emerging from changing climate conditions. The NWP recognises that firms have unique expertise and abilities to innovate for adaptation, which includes the creation or use of technology, as well as the development of financial mechanisms necessary to fund adaptation.

The database provided evidence of self-reported but actualised adaptation initiatives and linked them to firms' practices. The variety of locations and economic sectors represented provided a global perspective on adaptation among medium- and large-sized firms. The database helped to test the initial categories proposed by the conceptual framework of the thesis to characterise adaptation actions across different sectors. These categories were then taken into the grounded, field work phases of the research. In some cases, early indications of the rationale to take certain adaptive actions or project activities was explained by the firms. This helped to hypothesise the relationship between specific actions and investments and the different components of firms' business models, which would later be tested during fieldwork.

The characterisation of adaptive actions provided evidence on the beneficiaries of firms' adaptive actions, and the range of activities and contributions to adaptation. The case studies established a baseline of adaptation measures for the firms in the different economic sectors that would be later used to identify these actions in fieldwork and advance the empirical field data. The database is limited by the information reported by the firms, as it was not possible to verify the extent of the actions and activities of the firms. This bias will likely have led to an overemphasis on success stories, potentially exaggerated claims and partial information.

The coding processes of the adaptive actions were based on the characteristics and definitions established through the theoretical and empirical studies on adaptation and policy literature, where some actions do not exclude different categories and causality cannot be established. The relationship of different activities to components of the business model was defined based on the literature establishing business drivers as linked to calculations of cost, value or compliance with regulation. This strategy provided the closest indication and explanation for adaptive behaviour of firms based on economic drivers that have been well established by the literature. Several steps were followed to code, classify and analyse data.

1. Derived deductive codes and catalogue information
2. Created matrix of the initial coding to examine actions
3. Derived inductive codes using the data from the matrix
4. Synthesised to propose a private sector taxonomy of adaptive actions and signals

3.2.2 Deductive Coding

Each case study from the database – 100 in total – was downloaded in PDF format and uploaded to NVIVO qualitative analysis software. Next, each form describing private sector adaptation projects and measures, which ranged between 3-5 pages on average, was reviewed and individually coded. Following Hay (2000), the codes were first formulated deductively prior to collection, and later inductively by identifying common themes that emerged from the data (see Table 6 below). In each economic sector, adaptation projects were unpacked into multiple individual actions. During the review and coding, the careful and manual coding approach prevented double coding of the same type of adaptive actions in the same sector in different cases.

The following transcription of a case study, box 3 below, describes the adaptation actions of a large agricultural firm in Nicaragua. It provides an example of the rich information contained in each case study report on the database.

Box 3 UNFCCC Case Study "Chiles de Nicaragua"

Case study: Chiles de Nicaragua, S.A. "Strategic initiatives of adaptation to CC make a small business agro exporter sustainable as well as its value chain."


Chiles de Nicaragua, S.A.

Description of the project:

"The sustainability strategy, 2009 start-up year, is based on the necessary adaptation to climate change and was successful in reducing risks, the production like: droughts, floods, storms and damaged roads by heavy rainfall. Extreme weather events impacted the production chain before and natural events almost led to the bankruptcy of the company and its associate producers.

Besides this strategy, a new project started to produce chilli peppers using zero pesticides. This is achieved by the development of shade house and will reduce the vulnerability of the crop to the adverse effects of climate change. Furthermore, the possibility of an organic certification for the produce was examined.”

Climate Adaptation Actions:

1. Sharing of knowledge led to more favourable credit, technical, productive and associative conditions for other producers.
2. All suppliers signed a contract in which they agreed upon a set of regulations and rules. This included: a pre-established buying price and the producers should install irrigation system (preferably drip irrigation). This enables the company's agricultural cycle to be decoupled from the seasonality in precipitation. This allows the farmer to produce in the dry season, which indicates that the farmer is not influenced by the risk of flooding or dependency on rain-fed.
3. Plastic mulch technology has been implemented to increase water efficiency by reducing evaporation losses.
4. The project became part of the USAID's Program for Enterprises and Employment in Nicaragua for three years to strengthen the growth strategy for the company, which has been a key factor in boosting the company.
5. Cooperation was established with: Program Tecnología Agrícola Competitiva TECHNO LINKS (CIDA, MEDA and FOMIN). Besides that, a guarantee fund with national microfinance companies was created with FAMA and FDL
6. The project participated in the Regional Project for Adaptation to Climatic Change for the Corporate Sector, supported by IntegraRSE, GIZ and INCE, UnirRSE, among others, to analyse and identify the risks, opportunities and adaptation actions for CC, by using excellent tools and sharing experiences with other companies in the area.
7. The construction and implementation of 3 shaded houses led to the possibility of production under controlled conditions and reduced vulnerability to extreme temperatures and phytosanitary impacts.
8. Transport security is provided by the pick-up service of the company.
9. There is an active application being processed for the certification of organic chilis with controlled agriculture, the outcome of this process is expected at the end of 2013.
10. Increased regular visits of our technical team to our suppliers helps them in: a proper selection of the location for the crop, correctly transplant healthy and costly seedlings, supervising to ensure that the plots and ridges are well constructed to avoid flooding in the crop plantation area, that the irrigation system and plastic mulch are correctly installed, and that data is collected in a correct manner.
11. A strategic plan was created for the period of 2012-2015. The goal is to improve glitches in the Estrategias Empresariales ante el Cambio Climático en Centroamérica (Business strategies for climate change in Central America).

Expected Results:

1. Provide all suppliers with water-efficient irrigation systems and plastic mulch to allow them to produce year around and reduce water use.

2. Provide training to all directors and engineers on the topic of climate change and its possible consequences to support decision-making.

3. Provide 250 new producers, including 70 women, with drip-irrigation systems by the year 2016, with funding through the guarantee fund with Techno-Link for chili crops with extensions up to 1.5 mz.

4. Three shaded houses producing by the end of 2013, located in Managua, Boaco and Somoto, starting with 45 thousand pounds of produce.

5. Promoted good agricultural and manufacturing practices, and corporate social responsibility across the production chain, emphasising awareness and training of the actors on CC.

Indicators of achievement:

- 2012/2013: 205mz. producing (all suppliers).
- 211 producers use the water efficient drip irrigation system now on farms varying from 0.5 mz up to 42 mz.
- Increase of produce from 11.000 to 18.000 pound/mz due to the use of the drip-irrigation system and dry season production strategy.
- Regular visits from the technical team to the suppliers increased in the last three years from 2 to 5 visits a month.
- 30% of the actual producers use plastic mulch, some 60 mz.
- Establishment of trust: suppliers can show the contract to obtain credit for microfinance to invest system improvements.
- Construction of 3 shade houses by 2013 and the use of zero pesticides, in Managua, León and Somoto.
- Assisted an additional 250 suppliers, of which 70 were women, by 2016.

Adaptation sector: food, agriculture and forestry.

Adaptation activity: capacity building, climate resilient development, finance, monitoring, risk mapping and training.

Adaptation areas: adaptation planning and practice, data and observations, economic diversification, methods and tools, research and technologies for adaptation."

The cases were coded into the following initial deductive codes derived from the relational model (see Figure 6 below) and the literature review, and analysed using a matrix based on the different categories in each sector (see Table 6 below). For example, agricultural firms and actions that adjust business processes, or agricultural firms and actions that aim to provide training. It was through this iterative process that inductive codes began to emerge for the types of actions and the identification of the wide variety of associates or stakeholders involved. The result was a unique classification of adaptation actions that related these early adopters in different economic sectors and geographic locations to the different forms of adaptation responses, actions and stakeholders. The preliminary codes were chosen based on the literature and research questions (the full list is on Appendix 1):

- **Economic sector:** Agriculture, transport, tourism, etc.
- **Adaptive action**: Deploy technology, expertise, invest resources, raise awareness, etc.
- **Reported beneficiaries** of the adaptation projects: Focal firm, cooperative, farmers, experts, local professionals, local school or organisations, government ministries. These are all part of the local assemblage.
- **Business model component**: Marketing department, financial, operations, strategic planning, logistics, production.

The data classification started with this basic set of categories and grew to include more complex coding by grouping and associating actions to actors, components of the business model or assemblages to determine the reach of action (depending on the beneficiary or actor involved). These were further refined to draw out different elements of the business model. For example: categories based on actions emerging from one specific internal unit of the firm, such as marketing, client or government relations, human resources or business development.

The actions ranged from disaster risk reduction initiatives associated with climate adaptation to agricultural and farm management actions by business firms to mitigate climate change impacts on their suppliers' crops and along their supply chain. Other features different stakeholders, such as policy engagements to help local authorities develop climate adaptation incentives in their region of operations; partnering with financial institutions to develop innovative financial mechanisms to fund adaptation projects with the savings from mitigation activities; or establishing guarantee funds to protect local communities from the losses due to natural hazards.

Figure 6 Sample of Deductive Code

Firm	Actions	Contributions	Stakeholders
Chiles de Nicaragua	• Knowledge sharing • Build shaded house infrastructure • Implement plastic mulch technology • Engage in adaptation policy discussions	• Extend production to continue year round • Reduce water use • Build trust • Share with expertise	• Associate producers • Local Farmers • Directors and firm engineers • Local women's groups • Local and regional government

The matrix analysis of the final data from the cases studies across all sectors was used to develop the taxonomy of adaptive actions in the private sector (See Chapter IV). It also provided insight into the use of different resources and innovation in the private sector as part of this analysis. The matrix approach indicated a variety of links between specific firm actions and a range of associates and stakeholders acting at different scales and across different economic sectors. This resulted in new categories that allowed for hypothesising a rationale driving the adaptive actions, and connections to the business model of individual firms. For example, actions that included investment into community health programs to combat rising disease from climate-related impacts could be linked to the firm's ability to expand their social licence to operate in certain locations.

The results of the analysis revealed gaps where firms did not report adaptation actions. This provided a clear niche for further inquiry during field work. For example, in the case of the firm that grows organic chili peppers described previously, there were no documented actions that aim to contribute to adaptive capacity amongst the company's employees or clients. The results of this stage of the methodology were used in Chapter IV to validate the conceptual framework and to refine the research questions, as well as the selection of firms and locations.

The different categories of adaptive actions that emerged, such as operational or strategic, were among a variety of innovative activities of early adopters of adaptation planning. However, it must be noted that there was selection bias in choosing the NWP database. The case studies were self-reported activities of individual firms, which conformed to the reporting standards set by the UNFCCC. There is no evidence to explain why these firms reported the adaptation projects, nor is there a way to verify the accuracy of the information contained in those projects. Additionally, some economic sectors might be underrepresented in the database, as only a limited number of firms reported adaptation initiatives. However, this does not imply that fewer firms in those economic sectors undertook adaptation actions.

The second iteration of data coding connected different actions to the firm's internal business model components or external actors where the firm's influence or activities were being reported (a sample of the matrix results is in Annex II). The characterisation of adaptive actions was determined according to the firm's adaptation response and the scale of influence, depending on the associate or stakeholder involved.

- **Organizational Actions.** These shape the firm's capacity to adapt to climate impacts. These comprise private sector adaptation and organisational learning actions. These can be observed within the organisation and benefit the firm. For example, using climate data to determine location of critical infrastructure investments.

- **External Direct Actions**. These can shape direct associates' or stakeholders' abilities to use resources and information for adaptation, such as a supplier, employee, client, or government body. The focal firm's actions either deliberately or accidentally influence another actor directly linked to its operations. For example, when a firm's senior officer participates in policy or regulation processes aimed at improving disaster management responses or shaping the use of government resources for adaptation initiatives.

- External **Indirect Actions**. These actions shape indirect or undetermined actors' adaptive capacities; they are actions that can be transferred by a direct beneficiary to a third party. For example, actions that benefit an employee, such as emergency relief resources in case of natural hazards. The resources provide aid to the employee, but also his or her immediate family or household income.

The NVIVO coding process included individually coded adaptation actions, which were grouped and used to link firms or sectors to specific actors or actions (see Annex III). Table 4 above presented a sample of the matrix coding. The first column presents the name or abbreviation of the firm. The second column indicates the number of actions identified in each adaptation space according to the model above. The final column presents the number of individuals, groups or actors involved in the adaptation projects of each firm.

The analysis by sector and across the entire database provided rich information, allowing classification of the types of actions taken across different firms and their connections to business models, as well as potential influence on associates, stakeholders and wider host communities. The database analysis revealed that certain actions were (or could be) connected to a firm's business model drivers and indicated potential areas where business routines were reported to have been affected by climate change impacts. Most importantly, they revealed the variety of actors involved in the adaptation processes led by individual firms.

3.2.3 Case study selection

The matrix analysis results were used to choose the research sites and participants. The case study selection strategy deployed purposive a priori sampling (Miles and Huberman 1994). According to Curtis et al. (2000), qualitative sampling can be driven by evolving theory derived from emerging data. These case studies contribute to the geographic discipline research on adaptation by advancing in the systematic production of empirical data that strengthens social science (Flyvberg 2006). The type of firms and locations selected for field research were those that:

1. Operate in an economic sector highly vulnerable to climate and disaster risk;
2. Involve production tied to specific geographic locations or communities in areas of recognised vulnerability to climate change (this includes areas of increased natural hazards, variable temperatures and rising sea levels);
3. Have a wide variety of downstream and upstream associates and stakeholders active across various scales;
4. Have diverse business routines and cycles (short and long-term planning)
5. Have the potential to be accessed using personal networks or direct contact; and,
6. Have comparable organisational structures.

A final factor dictated that the research be feasible within time and budget restrictions for undertaking the field work. These factors guided the selection of two focal firms for field research. The focal firms acted as the starting point, with data collection and analysis expanding by mapping the different pathways, business routines, actions and resources in the firm's sphere of influence. This provided the boundary of the business model and the scope of the research.

The analysis of UNFCCC cases showed that organic agriculture farms and food and beverage firms, such as Scotch Whisky distilleries, were firms that had the desired characteristics and factors for the mapping of a variety of locations, relationships and inputs. They operate in climate vulnerable locations, have direct links with agricultural supply chains, work with cooperatives and use precision technology with both short- and long-term planning cycles. The table 5 below shows some of the preliminary factors assessed for each sector to determine the type of research participants for the field study.

Table 5 Case Study Selection Requirements.

UNFCCC Sectors – Requirements for Field Research Participants				
	Ease of Access	Accessible location	High diversity of associates and stakeholders	Clearly defined geographic location vulnerable to climate impacts
Agriculture	X	X	X	X
Consulting	X			
Chemicals				
Construction	X	X	X	
Finance				
Food and Beverage	X	X	X	X
Energy			X	
Finance			X	
ICT			X	
Retail				X
Science	X			
Tourism	X	X		X
Transport	X			
Mining			X	X

The table above shows that agriculture and firms in the food and beverage sector were ideal organisations for the research, with a multiplicity of relationships, highly vulnerable to climate impacts in identifiable geographic locations and a business model not linked to patents or secrecy protocols as the firms in the chemicals or ICT industries. Furthermore, these would have identifiable and multiple relationships with exchanges of resources and information that could generate sufficient data to test hypotheses and develop some theoretical propositions.

These case studies have been voluntary submitted to the UNFCCC database, which presupposes the firm had prior knowledge of climate change adaptation and developed a report based on the requirements of the database. However, no specific information was provided on the author of the reports, which might include firm's officers, international development experts or researchers working with the firms in developing adaptation related projects. These cases are outliers in the private sector, as having documented and reported adaptation, at least presupposes a notion of adaptation and the UNFCCC activities, which is an exception in the private sector rather than a rule. Also, the size of the firms and the locations, indicated that larger firms with international operations, including consultancies or large agricultural sector firms were mainly represented in their respective sectors.

3.2.3 Primary Data

The results of the secondary data analysis led to two different firms for further case studies, which conformed to the desired characteristics and combination of factors identified as central to answer the in-depth research questions on firm relationships and assemblages under climate stress. The first firm identified as a potential research participant was an organic production firm headquartered in California, U.S., with a supply chain of dozens of independent small farmers and a cooperative of approximately 160 farmers located along the Baja California peninsula in Mexico, a region with high levels of climate stress and disaster risk. The approximate reported annual revenue of the firm was over USD 100 million. This was an ideal case study because of the multiple upstream and downstream relationships, the geographic extent of the operations with relative proximity among the suppliers and the firm and the nature of organic farming, which requires the use of high-precision technology and routines to access a high-value market.

The second firm was a Scotch Whisky distillery with a supply chain of approximately 89 active local barley farmers organised in a cooperative located in the Highlands of Scotland in the agricultural region of the Black Isle. The region has been impacted by different climate and disaster risks, including hurricanes, and these are expected to increase over the next decades. This also allowed proximity to the storage and processing locations and to senior planners in the headquarters of the firm, and the quality of their products directly depend on climate conditions to access a high value market. This assemblage was also made of multiple upstream and downstream relationships.

The first case study's business model is premised on short-range planning cycles of production to maintain quality and value, with multiple harvests in one cycle, which meant the disruption of routines affected yearly quotas. Organic products demand immediate adaptive responses from the firm to manage climate stress. In the second case, the firm and cooperative operate with longer-term production cycles, where business routines and investment plans depend on one harvest and long-term storage of the final products. This requires longer-term investments and planning oriented to manage changing climate patterns. In both locations, the firms were clearly embedded in host communities through historical relationships with local farmers, families and the community. The firms were central to local economic development. This provided the basis for studying two assemblages and firms with similar business model characteristics, but with sufficient difference to draw important contrasts and examine adaptive actions in the context of adaptation.

After the desired firms and sites for study were selected, an initial direct contact was made with different senior officers of the firms. Several conference calls and discussions provided the opportunity to explain the aims of the research and the interest in their operations. It must be noted that a personal family background with farming communities was very helpful in gaining the trust of the directors of the firms, as both firms were historically connected to the farming community in their respective locations. A more detailed email and letter further explained the overall method and the proposed schedule for visiting and conducting field visits and interviews. The research invitation further explained that the intent was to provide a unique study and information for the senior planners of the firm in exchange for granting access.

Access to the firms was obtained on the basis of a technical explanation of the research. This included explaining the types of climate related impacts in their areas of operation, but also the potential benefits for the firm on reflecting on the impacts related to climate stressors in their operations. A copy of one of the communication emails with the barley cooperative is attached as Annex V. After preliminary contacts and conversations, trust was established with senior officers, and a snowball approach to key informant interviews and farmers in the cooperative was facilitated by the relationships in the community. While background and experience in field research served to accelerate access, overall interest in discussing risks related to climate in the firms, or for farmers to express their views on perceived impacts on their growing operations from climate and economic relationships with the firm, opened the space for interviews and field visits.

3.2.4 Key informant interviews and the relational framework

After the approval was granted by the firms' representatives, a preliminary desk review of their activities and background information on the sector was done to prepare in the months leading to field visits. These were all done in closed discussions and agreement with my first supervisor, who also provided important support and feedback during each stage of the research, including during the field research. A total of 5 months was dedicated to interviews, mapping and observing the operations between the two locations.

During the fieldwork, the initial interviews in both cases were used as opportunities for the co-production of information. This meant presenting the senior officers with the template of the firm's relationships and filling out the structure of the firm, names, locations and activities of their internal employees, planners and operations, and of their external associates, as well as indirect or direct funding sources. This was a particularly useful and creative exercise that helped the senior officers think about their operations from a new perspective, and to explain the different types of disruptions and problems emerging from increasing climate stress and natural hazards in their operations.

This process allowed for data collection, mapping of the firm's pathways and the population of different types of adaptation actions. Relational mapping for each firm was done in collaboration with the senior officers in each firm, local cooperatives and affiliate offices. This revealed the firms' locations of operations, preliminary identification of climate risks and adaptation actions.

Additional secondary data, such as technical and operational reports, was provided by the firms and used to fill gaps in relational model data. For example, training activities on water management in the context of climate adaptation were held for local suppliers to the focal firm and were recorded as actions in the supplier's relational space. The firms also provided geo-referenced information on their suppliers. This information was used to identify interviewees and profile farmers' locations, income levels and general areas of operations. The information also confirmed the boundary of the firm's operations by pinpointing related actors, the geographic locations of the firm's investments and the reach of their business routines. During the field work, a detailed field journal was used to collect information about the firms observed adaptive actions, flows of information, local innovations and relationships.

3.2.5 Semi-structured interviews and field journal

A series of semi-structured interviews were the main methodological tool used during field research. The key informants were identified during the first stage of interviews with senior officers and field officers, the relational framework was used to map both the structure of the organisation and the external assemblage of associates and stakeholders. The senior managers of both firms provided an overview of the company, the operations and investments (Macdonald and Hellgren 1998). The preliminary list of interviews was then expanded through a snowball approach (Denzin and Lincoln 2000) to include additional interviews with firm officers, associates, local government officials or officers in external organisations linked to the focal firm of study. A total of 68 interviews were carried out. In the table 6 below, all the positions and role of the interviewees identified through the framework are described. A detailed list of the interviewees in each case study is included in Annex IV.

Table 6 Key Informant Profiles

Key Informant Profiles	
Case 1 _Organics Firm/Farmer Cooperative	**Case 2_Farmer Cooperative/Scotch Whisky**
CEO	Directors
Directors	Sustainability Officer
Agro Science Researcher	Farmers
Technical experts	Malting firm CEO
Water specialists	Cooperative Employees and Members
Directors	Scottish Seed and Grain Officer
Farmers	Adaptation Institution
Local Government	Agricultural College Officer
Research Institution	

The interviews were voice- or video-recorded. However, in exceptional cases, with lower performing or income farmers that displayed anxiety or nervousness about being recorded an alternative strategy of note-taking was employed. All logs have been kept in booklets and daily transcriptions in electronic formats have been stored for safekeeping. A detailed field journal was also kept documenting locations and schedule of visits, observed resources, notes, comments and field site analysis of damage to infrastructure, locations that indicated risk or damage to land, crops or assets. The data collected daily was used to develop a map of the relationships, note the comments of different key information and record important information about the relationships. In the following page, photographs of one of the field journals is illustrates the detail of the information and organisation of the data. A photographic journal of daily fieldwork was kept, a sample from both case studies in shown in Annex VI.

The data protection rules and ethics have been strictly followed, with all video, audio and field notes have been saved in personal computer and password protected. The recordings were made directly in the same computer or in a mobile with the information backed up after each day to field work. These recordings have been filed in a backup drive for archive.

Figure 7 Field notes of interview session

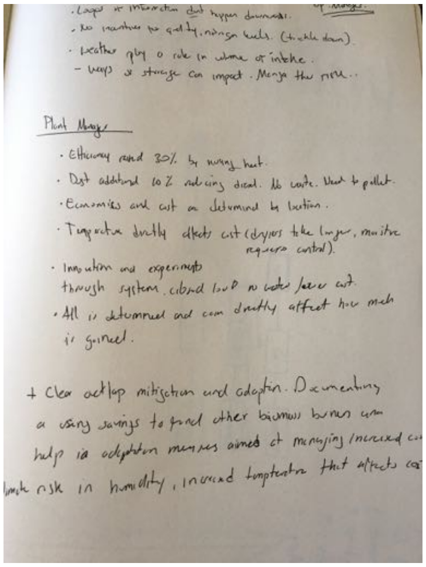


Figure 9 Interview questions

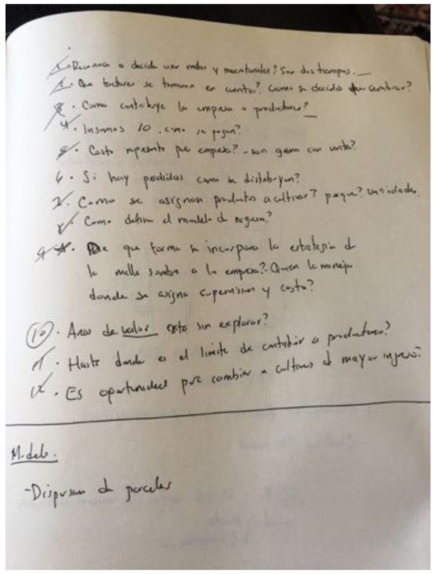


Figure 8 Scenario data points from field work

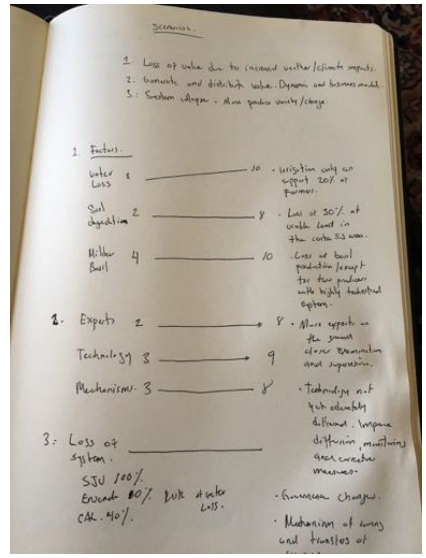
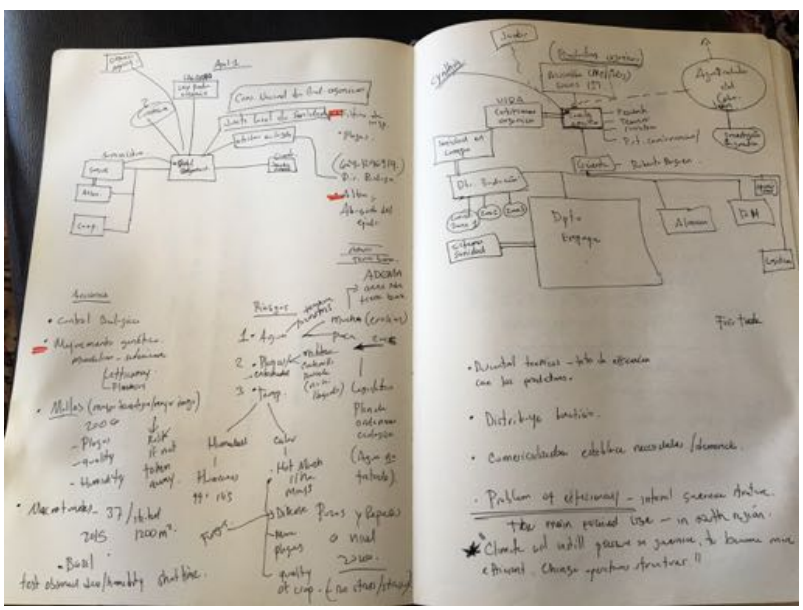


Figure 10 Relational mapping notes for assemblage boundary



3.2.6 Scenarios

According to Slawinski and Bansal (2012) firms that use scenario techniques broaden their repertoire of actions by allowing the introduction of diverse information into decision-making, so enhancing their ability to cope with change. Informed by future thinking, during this third stage of the methodology, a scenario exercise was used as a field data collection tool, where partially-generated scenarios informed by real world information from the firm's locations of operations were used in a scenario workshop with senior officers to explore adaptation options and measures to manage climate-related disruptions to business routines. The use of scenarios in this project was initially planned as a main methodological tool for in-depth analysis, however, limited access to senior managers and time constraints to carry out scenario sessions in all locations resulted in only using the method with the first participant firm.

Figure 11 Scenario Data Collection Session with Senior Managers

The successful scenario exercise was completed with the organic farm's six most senior officers at the company's headquarters. The senior managers oversaw international operations, logistics, sales, business planning, financial investments, local operations and marketing. The scenarios offered participants three possible future situations of extreme climate stress or disaster events along their operational routines, and they were asked to provide insight into the decision-making process and calculations that may be employed to stabilise the operation. This resulted in clear insights on the trade-offs and financial decisions that the firm would have taken to maintain control of production and normalise operations under increasing impacts of climate change.

The starting scenario presented climate and disaster risks in various geographical locations where the firm sourced raw materials. Then, guiding themes were used to explore options and potential actions of the firm. The guiding themes were: *1) Loss of value due to increased frequency of climate change impacts; 2) Generation and distribution of value resulting in enhanced adaptive capacity across sub-system; 3) sub-system collapse.* These three scenarios were generated by data from regional climate studies, field interviews and data from the field journal.

The exercise was presented as a way for senior officers to discuss the issues based on their experience and engage in a discussion very different in than a company meeting. The senior officers actively engaged by proving insights into their decision-making process and potential investments in response to the predicted climate stress scenarios. This was a helpful data-gathering tool, but it also proved to be a complicated method to use in circumstances of limited time due to the schedules of senior planners. The scenario workshop generated knowledge about the possible effectiveness of organisational strategies and served as an explorative and knowledge generation tool for the PhD research and the firm (See Annex 6 for the scenario presentation).

The scenario session was video-recorded for analysis. The key themes were identified during the session and later noted in the analysis. The exercise helped to develop relationships, facilitated an explanation to the participants on some key themes of climate change adaptation research and current work and introduced new information to the senior strategy committee on the adaptive actions and measures taken by firms in undertaking similar economic activities. The data generated from the scenarios was used to inform the analysis and validate the hypothesis that firms' economic calculations in the short-term would take precedence over some relationships. It also provided evidence on the types of reconfigurations they considered acceptable to maintain economic functions, and their answers provided evidence that was later used in a robust explanation of the challenges and constraints firms face in these circumstances considering their current business model and narrow entry points for information on climate adaptation planning and strategies that expand their view towards a wider social assemblage. My positionality as a researcher in the team was considered as external observer, and my questions were guided by genuine curiosity which help ensure pressure was not placed on the team to work towards specific solutions.

3.3 Ethics

A formal submission of a low-risk ethics research approval was presented to the ethics committee of Kings College London and approved by the Reach Ethics Panel on the 29th of July 2014. The application explained the methodology and the aims of the research. The research participants were informed in advance about the research aims and the general line of questions.

Three main steps were followed to cover ethical issues during the interview process: 1) Full disclosure to all participants at the start of the interview to avoid deception and assuring informed consent. The literature indicated that firms might want to leave adaptation actions undocumented to keep the information from their competitors and this was taken into consideration when requesting access. 2) Confidentiality was offered to participants, however none requested to be kept anonymous and all agreed to provide the information freely. The interviewees were asked if names should remain anonymous, but none asked for confidentiality. However, to maintain the ethical research standards described in the ethical approval form, the names of the individuals quoted do remain anonymous.

3.4 Participant feedback

A final research report with the key findings was provided to the Chief Executive Officer and senior planners of Jacobs Farm. The senior officers provided detailed feedback on the report, confirming the analysis in most findings, and adding further rationale for the failures or success in adopting innovations or undertaking adjustments as adaptive actions. The report included details of previously undocumented uses of technology and challenges in the diffusion of local innovations.

The report also proposed a set of recommendations based on successful technologies and the experiences of different individuals and farmers in locations of high vulnerability to climate impacts along the supply chain. The CEO and senior officers of the firm validated the findings and noted that the same problems persist in their operations. The report contributed to introducing new information and promoting a discussion on adaptation planning among the different decision-makers in the firm.

Due to time constraints, it was not possible to prepare a report for Highland Grain and the Distillery in Scotland. While a conversation was established with the CEO of the cooperative, it was not possible to finalise the report with the minimum information to provide a valid input into the organization.

3.5 Validity

According to Guba and Lincoln (1981) the qualitative research paradigm requires specific criteria to establish rigour, which should be supported by tangible evidence, through various strategies, such as peer debriefing, memos, continuous observation and engagement in research locations. In the previous sections of this chapter, photographic evidence of the field journals and memos provided evidence of the observations and engagements in the research sites, as well as, photographic evidence is provided in the following empirical chapters. During the field research, debriefing sessions were held every week or two weeks with the primary supervisor to review and update on progress, research interviews and preliminary findings. This was a critical part of the field research and helped to maintain continuous revisions of research design and appropriateness of collection methods.

Qualitative research is an iterative rather than linear process, were the researcher moves between design and implementation to assure consistency in question formulation, literature reviews, research participant recruitment and data collection strategies, and finally analysis (Morse 2002: p. 17). The iterative process during the doctoral work was integral to the research design and analysis, as progression through the different stages required reviewing and considering emerging characteristics of the data, and new findings to consider in case selection, or participant recruitment. According to Kvale (1989) to validate is to investigate, to check, to question, and to theorize, and the research process of this doctoral thesis has been driven by the emerging empirical data, from secondary sources to the interview process in different locations.

The conclusions of the PhD provide a theoretical contribution that represents the summary of the iterative research process, where reflections on positionality of the researcher and reliability of the data have been considered throughout the research by reflecting on the biases on positive examples of adaptive behaviour, or the risk of overstating the findings. Therefore, the conclusions recognise the limits of the work and highlight the novelty of researching private sector engagements in adaptation, which appear as descriptive and technical, but opened the potential for theorizing about transformative processes in the economic relationships of small, medium and large firms.

In social geography, to ensure rigour it is necessary to provide information on the appropriateness of the methodology, the use of multiple methods, details on on respondent selection and the presentation of verbatim quotations (Baxter and Eyles 1996). These strategies have been integrated into this methodology, and detailed explanation on case selection criteria, communications with research participants and access to research location, have been explained to assist in providing rigour to the thesis. In the empirical chapters, verbatim quotations have been used sparsely to demonstrate the perceptions and views of different respondents, both from the firms, and the surrounding assemblages. The standardised interview guides and reflection on the power dynamics, both between the researcher and the interviews, but also between the firm and the external stakeholders, where paramount to the research design and implementation, these enhanced rigour in the research practice (Cooper 1995).

CHAPTER IV

A taxonomy of adaptive actions in the private sector

Introduction

The conceptual framework guided the analysis of the one-hundred entries in the UNFCCC private sector database. The self-reported adaptation projects of individual firms covered various industries and geographic locations. The reports provided real-world examples of different types of adaptation by firms' associates and stakeholders involved in early adaptation responses, as told by early adopters that had knowledge of adaptation-related projects. In each sector, different forms of adaptive actions and innovations presented a broad view of individual firm adaptation mechanisms deployed in assemblages at various local scales.

These cases highlighted small, medium and large firm's adaptive actions, demonstrating the ways in which these economic agents engage with a variety of individuals, groups and organisations in response to climate impacts. The analysis revealed how economic agents codified information, distributed and invested resources, used technology or partnered with external actors for adaptation. The analysis resulted in a taxonomy of adaptive actions generated from coding the reported adaptation projects.

The classification guided more robust analysis of individual firm's adaptive actions, drivers and consequences during the subsequent fieldwork (reported in Chapters V to VII). The classification revealed clear examples of the connections between adaptive actions and business model sub-components and business routines. The data provided empirical evidence on individual firm's responses to climate stimuli and the actors in their sphere of influence. The analysis of the data was guided by three questions, which aimed to identify and unpack individual actions, mechanisms and components of multiple economic assemblages under climate stress:

- What are the types of climate adaptive actions reported by private sector firms?
- Why are the adaptive resources deployed? And how?
- What are the connections of adaptive actions to business model components? And how firms codify and share information?

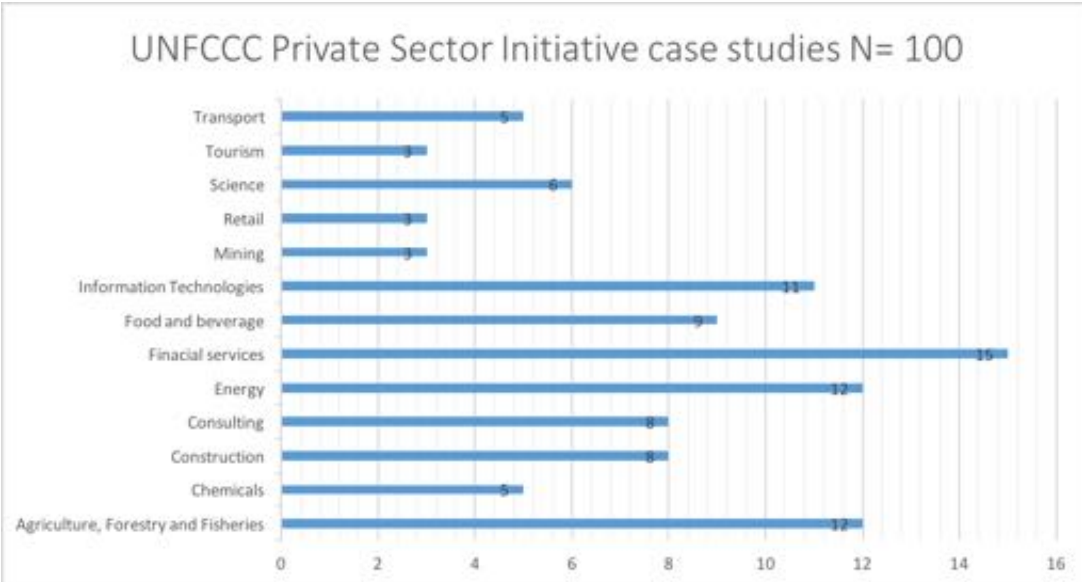
The analysis in this chapter synthesises information from the different economic sectors represented in the firm database to reveal the adaptive actions of individual firms, in order to determine the different ways in which firms codify information, deploy resources and engage in adaptive behaviour at the community level. This analysis provided a map of the elements, relationships and actors that constituted social and economic assemblages, and so tested the appropriateness of the framework for understanding the adaptive behaviour of firm assemblages.

4.1 Overview of Adaptation Actions and Early adopters

Individual adaptive actions can be observed within firms' changing business routines in response to perceived or expected climate impacts. The types of actions observed in the database included routine adjustments to integrate new technologies or information, innovation at the local level in response to climate variations or disaster risks, development of strategies to manage future climate risks or deployment of specific resources to stabilise existing business routines. The literature indicated that firms are unlikely to identify, document or report on adaptation actions due to lack of time or resources (UNGC, 2012) or the incremental nature of many adaptations, which may lead firms to consider these actions as routine responses to external pressures rather than as strategic adaptation actions.

The firms which documented and reported adaptation projects to the UNFCCC are early adopters of adaptation measures, as innovation theory defines efforts to document and diffuse information to be characteristics of innovators and early adopters of innovations (Rogers, 1987: p.249). These firms have to first recognised adaptation as concept and identified those operations were increased levels of climate and disaster impacts have begun to alter routine operations, and further overcome the limit of assigning resources to document adaptive actions. According to the categories of innovators the organizations documenting, and reporting adaptation projects can be categorised as innovators or early adopters. These firms have in some degree altered a process, practice or integrated new technologies to cope with climate impacts and identified the UNFCCC database, wither through a fund or partnerships, which potentially will have knowledge of the basic concepts of adaptation.

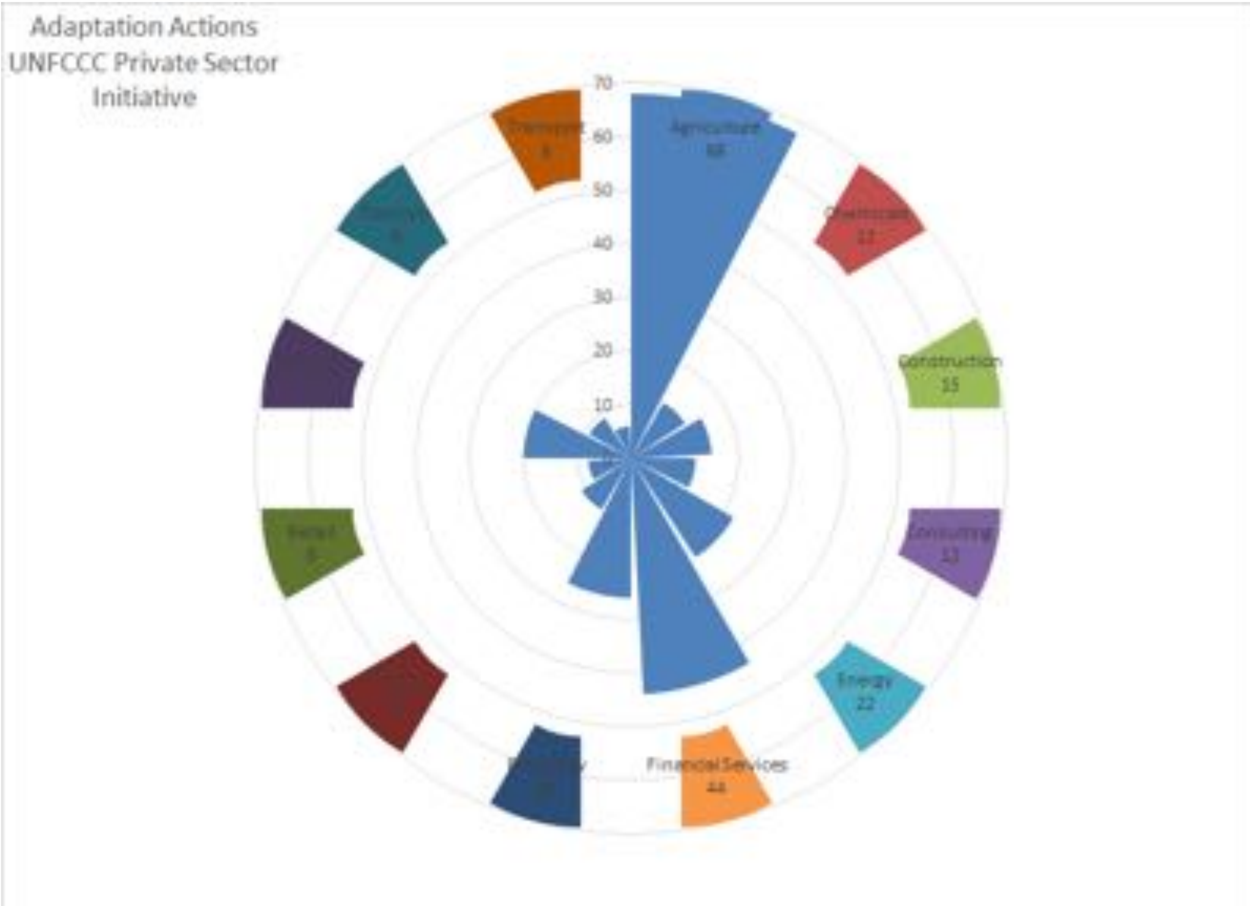
Figure 12 UNFCCC Private Sector Database Case Studies



The UNFCCC database contains recent, observable and documented adaptation projects in the private sector. The database is described in Figure 12. A complete list of individual firms and codes is attached in Annex I. The total number case studies analysed were N=100. Most of the firms that documented and reported adaptation projects were in the financial services, agriculture, information technology and energy sectors.

In these sectors, firms are highly vulnerable to climate change impacts or have begun to take advantage of emerging business opportunities presented by changing climate patterns, like expanding the financial services they offer or developing new technologies to support adaptation, such as weather monitoring services, or the energy sector where investments in infrastructure and protection measures for critical assets have become part of firms adaptation strategies in long-term investment planning.

Figure 13 Adaptive Actions by Economic Sector



The Figure 13 above shows the diversity of adaptive actions coded in each economic sector, where each case study has submitted information in the UNFCCC form to comply with the minimum requirements to be considered as adaptation activities or projects. The high number of adaptive actions in the agriculture sector is explained by the direct impacts on growing operations, and in the financial sector by the emerging business opportunities from climate change along the linkages to a wide array of external associates and stakeholders. For example, financial firms reported broadening services that provided insurance or financing to firms or individuals in other economic industries, such as agriculture, food and beverage or in the energy sector.

The different adaptation projects confirmed that early adopters identified value in using adaptive actions as a mechanism for adjusting subcomponents of their business models to changing climate patterns and natural hazards. These adjustments included making changes or allocating resources towards enhancing the organisational capacity of the firm, or the capacity of its associates or stakeholders. The degree of these adjustments suggested the types of shifts that business models are undergoing to cope with climate stress and what consequences may be experienced in the firms' direct and indirect social and economic relationships.

The adaptation initiatives that entailed changes to business routines, targeted investments or the integration of technology were determined by economic calculations of cost and value. However, innovative adaptation projects were motivated by longer-term social and environmental risk reduction considerations. For example, in the tourism sector, morphological transformations of the landscape, such as permanent alterations in the geography and changes in vegetation due to residing ice shelf or increased flooding have led to a loss of climbing and hiking trails over the winter months for a firm in the Italian Alps (K3). This led the firm to reconfigure their business model to accommodate for the loss of profits. The firm adjusted their cost structure and invested in equipment to expand into new mountaineering activities that were offered earlier in the tourist season.

In the finance sector, a firm (F4) undertook community-based investments in partnership with the local government to assist remote communities in acquiring and installing radio towers, power generators and emergency boats to transport children to school due to recurring flooding in the area. These actions improved disaster relief communications and enhanced local resilience to floods in the remote villages of the Brazilian amazon that saw the investments.

In the agriculture, food and beverage and finance sectors, firms undertook multiple and complementary activities in their adaptation strategies, including leveraging the capabilities of external firms when these were needed. In the food and beverage sector firms are closely intertwined with the agricultural firms that provide the primary inputs for their beverages, processed foods and other food products. These industries are highly likely to incrementally experience uncertainty as indirect impacts of climate affect their associates along supply chains. The resources used to build economic and social adaptive capacity in these sectors were often developed in partnership and cooperation with key associates. Table 9 presents the individual types of adaptive actions in each economic sector and the actors involved (see Chapter III for definitions).

Differentiating between adaptive actions in this way depended on the reported primary focus of a firm's adaptation project. The first-order adaptation actions, for example, indicated that climate or market signals led to the adjustment of internal routines or deployment of resources to maintain internal organisational stability, creating adaptation space for the firm. With second-order, the firm's adaptation actions occurred in response to indirect impacts on the firm through associates forming part of their economic assemblage. This classification includes adaptation actions that contributed to and influenced direct associates within their sphere of influence, such as suppliers, employees, or clients. The third-order describes activities focused on undetermined beneficiaries, who could potentially be dispersed in time and space with adaptation action contributing to the public good.

Table 7 Adaptive Actions by Sector

Sector	Total Actions Identified	Focus of Adaptive Actions		
		Firm	Associates	Stakeholders
Agriculture, Fisheries and Forestry	68	14	38	16
Chemicals	12	8	3	2
Construction	15	2	7	1
Consulting	12	2	17	0
Energy and utilities	22	15	7	2
Financial Services	44	11	26	13
Food and Beverage	26	7	15	2
Information Technologies	11	2	15	3
Transport	6	0	0	0
Tourism	9	0	0	0
TOTAL	225	61	128	42

The model proposed by Berkhout at al. (2013) examined the adaptation space of the individual firm. In the original model (described in Chapter 3), the firm reacted to climate or market signals from climate stimuli it had reinterpreted to adjust its business routines, triggering an internal learning processes and shaping the firm's adaptation space. In a relational view of adaptation proposed by this thesis, the firm is a source of signals that influence a variety of associates and stakeholders through its adaptive actions and resource deployment.

Table 9 above indicated that firms in economic sectors highly sensitive to climate impacts undertook actions to develop adaptation space beyond the firm. Their adaptive actions supported adaptation outside of the firm, both among their direct associates and towards undetermined community members. This confirmed the firm's ability to widen the scope of adaptation by connecting climate change measures to business drivers. Innovation was not solely focused on the capacities and options of the firm, but also on those of the people, groups and locations where they operated, drew value or sourced materials.

The process by which these firms recognised their interdependence and connections to other actors could be identified in the data. How and why firms undertook certain adaptive responses, and how information and resources were allocated to forms of adaptive actions were the questions identified during the global scan that later drove the fieldwork.

In the financial sector, banking institutions, insurance companies and investment funds have begun offering new products and services that prompted changes in these firms' business models by expanding market services for associates and new clients, such as customised insurance services for the tourism sector or guaranteed funds for micro-insurance banks, as well as providing new investment vehicles to support adaptation projects.

These firms provided intelligence services to current clients through comprehensive climate risk assessments and advising. Their role has expanded to integrate climate data into their financial models, which indicates the normalisation of adaptation planning into the business routines of the firms and among their associates or clients.

The analysis highlights the changes in business configurations in response to perceived or expected climate and disaster impacts. The examples gradually provided indication of the linkages between the biophysical impacts of climate change, business routines and business model components, which pointed to the role of economic agency in shaping local adaptation processes.

4.2 A taxonomy of adaptive actions in the private sector

The data was used to propose nine initial types of adaptive actions in the private sector in response to observed climate or disaster impacts. This taxonomy is a preliminary list of individual actions, which allowed for examination of the mechanisms economic agents use to respond to climate stress. Table 10 below is a result of the analysis of the UNFCCC data. These categories are not mutually exclusive and were observed as complementary or occurring simultaneously in a variety of private sector adaptive responses. In the following chapters, the actor-centred analysis illustrates through empirical evidence the relationships between types of adaptive actions and adaptive capacity.

Table 8 A taxonomy of Adaptive Actions of the Private Sector

Type of Adaptive Action	Category	Description	Examples
	Operational	These are adaptation actions that have been documented or identified in existing business routines of individual business. These are resources, processes or activities that have not been explicitly recognized as adaptation measures by the	Monitoring appearance of diseases; supervising construction of plots and ridges; embedding CC considerations into business processes and ‘hard’ adaptation measures.

Business Model Actions		firm, but after examination have shown to contribute to adaptive capacity in different ways. These can also be gradual adjustments of subsets of business routines that are embedded in the wider system.	
	Strategic	The adaptation actions are those operational routines which have been explicitly identified by individual business as aligned to adaptation measures. They require longer-range practices and combine resources and expertise from various operational departments. (Including CEO or senior management involvement).	Strategizing to reduce disproportionate dependence of rural households on land to support livelihoods; restoring surrounding ecosystem in critical infrastructure location rather than building storm water management.
Knowledge and Learning Actions	Experimental	These are actions not currently configured into the firm's business model or routines and can include new partnership or innovation at the operational or strategic levels. They are actions which seek to test out new processes or resources to guard against perceived or expected climate impacts.	Linking adaptation to the voluntary carbon market.
	Technological	These actions incorporate or combine the use of human expertise with technological tools for improving business routines or developing adaptation strategies.	Deploying technologies to monitor weather patterns or measure climate change-related variables of heat, humidity; GIS resources for adaptation decision-making.
Normative Actions	Prescriptive	These actions denoted business-dominant views or normative views on adaptation deployed through different corporate mechanisms.	Introducing a family planning campaign as an adaptation measure; delivering programs for farmers using radio and training.
	Policy Engagements	These actions are aimed at improving or shaping local or regional policy or regulations on disaster risk reduction or climate change. These improvements might	Participating in forums or high-level panels on adaptation; providing expertise on local

		focus on facilitating economic environment for investing in adaptation, or in more socially aligned forms of contributions using the firm's technical capabilities to inform regional policies.	disaster and climate change management regulation.
Resource transfer actions	Mixed (CCA-Mitigation)	These are those actions that complement each other, building on existing green technology or energy initiatives with consequence to either mitigation or adaptation.	Allocating a percentage of firm income to association; a unique example of using mitigation (capturing carbon) to fund adaptation.
Structure Changing Actions	Transformative	These actions reconfigure legal, social, economic or environmental elements of a regional or local system. There are observable changes in the existing reality of local geographies.	Transforming a partnership into independent non-profit organisation.

In the following sections these categories are elaborated upon through the use of real-world examples that illustrate connections to the firm's business model by examining specific areas within the firm, such as the direct involvement of experts in specific departments, the allocation of resources or the described purpose of technical or social solutions to climate impacts and weather extremes. The analysis shows the connection of these actions to a variety of stakeholders and associates, which range from individuals, local groups and organisations to wider communities.

Adaptive actions by firms can be evaluated in terms of their potential contribution or ability to influence distinct dimensions of adaptive capacities of assemblages by facilitating access to information, participating in local decision-making for adaptation, sharing financial value or expanding economic opportunities. This suggests which firms might widen or narrow the adaptation spaces of different actors forming part of the local assemblages.

In cases such as policy engagements or prescriptive types of actions, the firms might act on their behalf exerting their view of desired forms adaptation and preferred adaptation trajectories based on business model calculations of value and profit or might move towards recognising a social form of adaptation, allowing for inclusive and transparent forms of engagement to cooperate with local actors. These types of actions identified in the reports, solely provide evidence on the actions, the drivers and motivations are operating on the basis of current business models intended to protect the profits and growth in the private sector. The classification was useful for determining the scope and location of responses to climate stimuli, which allowed for the unpacking of adaptive actions reported in the different adaptation projects into means-end chains. The data generated from the projects of early adopters provided key information to propose the taxonomy and guide the field-level interviews.

4.2.1 Operational Adaptive Actions

The operational adaptive actions identified were adjustments or shifts in the daily business routines of firms, including knowledge or information management activities, production operations, service delivery, monitoring and logistics. The adjustments made pointed to the different components of the business model undergoing shifts or disruptions, either in different geographic locations or moments in time, from climate and extreme weather events. The responses to these interruptions were normalised by incorporating adaptive thinking into the firm's operations. There are examples of these field-level adjustments and of the deployment of resources to assist firms and associates in coping with perceived climate impacts along supply chains; most of which are in developing regions. The locations ranged from Nicaragua and Colombia in Latin America, to Uganda in Africa and India and Nepal in Asia (A1-A7).

For example, several adaptive actions reinforced monitoring practices and routines to improve plant health (A1, A2, A4). Others increased the number of technical experts deployed to work in the field (A4, A7) to improve agroforestry practices in highly vulnerable locations (A1) or the selection of locations to plant crops (A3) to enhance nutrient delivery. Improved water efficiency (FB3) and better data collection to support local decision-making (E4, F13, I11, CS8), including the development of new methods of communication and consultation with local stakeholders (FB6), were also noted as examples of this type of adaptive action. These incremental adjustments in response to changing climate conditions were required responses to protect assets and people. The actions taken suggest that firms recognised the need to provide support to different stakeholders to sustain production and improve operations under uncertain conditions. The operational forms of adaptive actions were reported as directly contributing to improvements in efficiency and decision-making on the ground. They are also connected to cost calculations and sales projections within specific business models, providing a first indication of the connection of adaptation-type responses to the firm's internal architecture.

The codified field data on firms' operational routines was converted into economic or financial calculations to inform strategic decision-making, including identifying emerging opportunities that required the realignment of business interests, which widened the adaptation space. For example, in the construction sector, individual firms that characteristically operate with long investment cycles to plan for high levels of investment in physical infrastructure projects indicated that several technical adaptive actions were incorporated into established business routines, suggesting internal shifts had triggered that organisational learning processes (Co4, Co6). These are forms of integrating adaptation planning into infrastructure designs after experiences and information feedbacks, which is a second- or third-order learning loop.

The changes in routines reconfigured individual firms' relationships with their clients by extending the provision of services for new projects and beginning work with local governments (Co2, Co5). The examples suggest that incremental adjustments and the integration of climate change adaptation planning provided sources of value for the firm and widened their economic relationships. The adjustments also widened the adaptation space by allowing firms to generate additional financial resources or information from operational activities, moving concern for adaptation from the field operations level into senior or management activities.

In the consultancy sector, firms reported focused briefings to senior managers (C3), which suggested exchanges of information had occurred between senior planners to identify and incorporate adaptation opportunities and ideas into daily operations. The requirement for specific coding or formats of information by the firm's decision makers enabled them to normalise the minor operational adjustments into broader business calculations that considered the changes in routines as necessary to their model.

Some of the operational-level actions required new investments or resources. The operational actions are indicators of the individuals or processes that act as receptors of climate messaging, which comes from current climate-related stimuli or minor shocks from natural hazards that occur within a parameter of daily adjustments and require no specific planning or strategic combination of resources.

A transition from operational to strategic highlighted the degree of integration or trajectory that different types of operational adaptation actions might follow. For example, in the energy sector, operational actions shifted or transitioned into strategic actions when moving from protecting one local asset to implementing a strategy to protect all current and future assets in locations of high climate risks (E1, E4 and E5). This is explained by the business imperative of planning asset and infrastructure investments decades into the future, which forces a closer examination of the lessons learned from operational actions under the lens of changing climate conditions.

The reported actions integrated into firms' long-range planning horizons suggested a familiarity with the climate change mitigation agenda that prompted these firms to recognise that acting with longer timeframes in mind can enhance their operational security. The mitigation agenda became a driving force in the private sector because of the possibility to reduce operational costs; adaptation, however, is about maintaining value. The different adaptive actions suggested that changes to organisational routines, such as the relocation of business and data centres used to safeguard firm information (E1, E4, E5), occurred because of firms' perceptions of the potential impact of climate risks on critical assets with high operational value. These perceptions triggered internal changes that gradually normalised planning routines into organisational practices within the firm (E1).

The use of information technologies like Geographic Information Systems (GIS) and technical expertise to model potential changes in climate and physical conditions that might affect a firm's service area (E1, E3, E4) suggested that climate data and local geographic calculations were used for adaptation planning, with dimensions of time and space recognised by senior planners in these organisations as critical for informing business decisions and business model configurations.

In the food and beverage sector, the operational actions taken indicated a distinction within the organisation between the integration of climate information and the consideration of emerging opportunities, which was done by different internal business units of the firm (FB6) such as logistics and sales in decision-making processes. In each individual component and operational routine of the firm, planners aligned their operations with adaptation planning. The same firm (FB6) devised relevant indicators for their adaptation priorities and established a communication strategy for their internal units that aligned the firm's priorities with adaptation. This provided a baseline for the firm to work towards in enhancing their adaptation activities while simultaneously providing incentives for the directors, senior officers and coordinators for implementing adaptation measures.

This suggested a firm's ability to recognise the signals from the current or potential climate stimuli that were likely to impact business routines by diminishing the production capabilities of their direct associates. This required firms to put emphasis on food and water security (F2, F3, F6) of their host communities, for example, which was driven by wider stakeholder engagement and strategic investments in vulnerable areas of operations.

4.2.2 Strategic Adaptive Actions

The operational type of adaptive actions provided evidence of on-site adjustments to business routines in response to perceived climate stimuli. The strategic actions suggested a combination of foresight and investments that focused on resource allocation through deliberate decision-making at multiple levels and timeframes. Strategic actions combined resources, expertise and long-term purpose. They required investment and the active involvement of senior planners to authorise changes in the business model or configurations of the firm's relationships. Firms deliberately pursued adaptation options, providing a baseline for establishing indicators of success, such as securing additional financial value, reducing risks on critical assets or expanding the firm's social licence in key locations vulnerable to climate impacts (Co1-Co7). Deploying resources to support these actions required foresight and planning and the reconfiguration or rearrangement of parts of the firm or the assemblage, including changing the locations of suppliers or infrastructure, repurposing land uses or altering the legal structure of the firm to accommodate new adaptation-oriented activities.

The deliberate long-range plans started as routine operational adjustments that developed into strategic actions. For example, in the construction sector, strategic changes were reflected in road design and building and infrastructure construction (Co4), in the types of materials (Co6) integrated into construction systems to reduce flood risks and resist thermal pressure, or in improvements to raise and sustain water efficiency (Co6). The experiences with disaster events led to knowledge created within firms that triggered innovation in their business models, as suggested by firms integrating flood protection and long-term sea level rise calculations in new reconstruction projects (Co7), which also increased the value of their services.

The designs of the firm in New Orleans were informed by the results of inspections of damaged buildings in the local community after a flood and cooperation with the city's recovery management office (Co7). While the principles of climate-resilient infrastructure design may be common practice, integrating assessments of local conditions after engaging with local authorities and calculating past damages clearly aligned the firm's operational routines with strategic adaptive actions. The feedback loops of information suggested firms developed longer-term, normalised adaptation planning processes, which they incorporated into business model components related to the costs and design in order to generate value for the firm and clients. The broader community also benefited through the advancement of local regulations that featured more resilient building practices.

These activities demonstrated a conversion of technical information into new operational routines that contributed to strengthening the climate change adaptive capacities of different stakeholders. The firm's use of climate sensitive designs influenced external actors, including clients and government initiatives, and aimed to improve the capacity of construction to withstand extreme climate events (Co4). In this case, the firm relied on expertise to develop the alterations to their internal routines related to infrastructure design standards.

The adaptive actions of construction firms were identifiable across the different scales. In the above example, firm changes could be observed within the senior management team, who determined that adaptation planning was an essential component for project design that required adding elements to the business model to seize a market opportunity and expand their potential to deliver higher value for clients.

The additional space created for professionals to jointly develop technical solutions for climate-sensitive infrastructure with the firm demonstrates how these actions contributed to a variety of direct associates reinforcement of their construction projects. Finally, the ability of indirect stakeholders to influence policy and regulation was enhanced through the contribution to creating minimum operational requirements necessary for mitigating climate and disaster risks in future infrastructure projects.

In the energy sector, strategic adaptive actions focused on developing well-informed measures to protect infrastructure and critical assets (E5, E6). The planning horizon of these types of firms extended beyond yearly planning cycles to include future decades. For example, Entergy (E5) used scenarios to analyse expected risks 20 to 50 years in the future in order to safeguard business operations, generate stability in the firm and, consequently, raise investors' confidence.

The strategic planning horizon in the energy sector is unlike those in other industries due to the high levels of investment and fixed infrastructure. Routinely working with these longer timeframes facilitated the incorporation of climate change risk planning into business functions and business models. The ability of planners and officers to justify adaptive actions as protecting the firm's value helped to overcome any resistance to changes in their business configurations, which might be experienced in other industries when new investments and expertise are introduced into currently stable business routines.

Strategic actions also took form of new climate adaptation-related services for other sectors where the expansion of the firm's business model moved towards extracting value from economic activities in areas of emerging climatic change-related risks and needs. For example, in the information and communications technologies (ICT) sector, the expansion of services like remote sensing and disaster alert systems (I2, I3, I11, S1) indicated that firms were aligning action with market opportunities linked to climate adaptation. Firms in the ICT sector play a critical role in providing and disseminating accurate information and data among local actors to support decision-making under disaster risk. Partnerships with firms in the agricultural sector, local government offices and financial service firms are at the core of new business model practices. ICT firms focused primarily on innovative services that provided complementary capabilities for other firms through specific project-based collaboration.

In the chemicals sector, strategic actions sought to provide additional services to a wide assemblage of actors across geographic locations. Analysis of the projects in the chemicals sector revealed that firms were integrating actions into their business models, such as the development of new products for the market (C1-C5), that allowed them to derive financial value from adaptation. Adaptation actions in this sector are comparable to the incorporation of clean energy and green technology; so-called "eco-innovation" in business models, which creates value for the firm that adopts mitigation activities.

Firms in the chemical sector that reported creating new chemical products targeted at the adaptation market, such as new stress tolerant plants and seeds (C1, C2, C3) or chemical foams that can be dispersed to absorb the force of waves and floods (C1) in coastal areas. These firms didn't report any engagement with key stakeholders in these cases, solely client-oriented actions. Innovating business models to develop capacity to expand into new market opportunities through the provision of new products and services to external clients resulted in adaptation actions that focused on the firm. The new products would have required changes in the internal operational routines that aligned their research and development activities with product development for adaptation markets. The potential to enhance external sources of value for the firm drove efforts to document and communicate products that could be used in adaptation projects in other sectors,

In these cases, the potential for future market opportunities suggests these firms were motivated to undertake research and development activities. Confidentiality was paramount to their business model in order to protect new product patents. Their products' benefits were communicated, however, to facilitate the diffusion of their innovations throughout other industries, including agriculture and finance, which was an acceptable and desirable diffusion of information and could increase firm value and investor confidence. The absence of any reported partnerships or collaborations suggests that economic considerations were the sole motivator for developing the emerging technological solutions for adaptation.

The linkages to value creation suggested a business model seeking to generate maximum shareholder profits and indicated that firms in this sector primarily sought the opportunities presented by climate change. These firms utilised pathways or connections to clients to draw value from adaptive actions through products and services aimed at adaptation, which explains the incremental change and slow alignment of the organisations' relationships with customers to their broader adaptation needs. The focus on external adaptation remains limited to developing products for long-term climatic uncertainty in the agricultural sector and disaster risk solutions as in the type of coastal protection chemicals (C1).

A firm (C5) with warehouses in Houston, Texas, in the United States provides a notable example of broader adaptation actions. The firm's planners chose to restore the local ecosystem at the site of their operations as an alternative to building storm water management infrastructure, which indicated an integrated or holistic approach to adaptation that contributed to ecosystem restoration including a carbon sink. The project reported that senior planners recognised that the loss of watersheds around their plant had resulted in higher risk of flooding. The firm decided to engage in a multi-stakeholder project where economic calculations and external capabilities provided by the Centre for Resilience at Ohio State University led to the analysis, design and restoration of the wetlands. Their first objective was to protect critical assets but demonstrating the environmental and social value of their project to local regulatory stakeholders like the city government, public works department and other agencies was also a stated objective of the project. This project leveraged the complementary capabilities of a local knowledge broker (the university) and utilised the necessary information introduced to integrate adaptation planning into a long-term view of risk management investments.

The combination of actions revealed a strategic view towards adaptation. Multiple complementary activities, investments and relationships resulted in the creation of both environmental value for the community and economic value for the firm. These measures directly reduced the risk of flooding and lowered projections of future costs from climate impacts on the firms' infrastructure. The project contributed to the preservation of natural protective barriers that benefited ecological diversity in the host community. The firm drew information and financial support for adaptation actions from its collaboration in the context of a social response and contribution. The firm also developed adaptive capacity and enhanced its social licence among the community, which had been identified as a key driver for the firm's engagement in climate adaptation activities.

The strategic adaptation action taken suggests that several areas within the firm planned and deployed resources to develop adaptation options. Improving the firm's ability to sustain such operations would require a combination of material resources, routine changes and support from external actors. The holistic approach to adaptation indicates that direct and indirect climate impacts affected multiple dimensions of a firm's functions, whether by raising costs related to reinforcing necessary infrastructure or narrowing adaptation space in the host communities, where firms perceived climate-related risk could lead to losses in productivity.

Strategic adaptive actions can also be seen in the agricultural sector. Many large agricultural firms buying diverse crops from small farmers connect small and medium farms to international markets through their supply chain. These firms have invested in increasing efficiency to protect the quality of crops and the volume of the harvest at farm level to maintain sale prices and revenue (A1-A5). These forms of economic calculations will be based on market dynamics, both global changes that determine prices of each type of crop, to the local markets where individual or family sized farming operations will be part of the supply chains. The decisions of these firms will have almost immediate repercussions in different communities, with presumably high performers maintaining or adapting to any changes in markets, or lower performers losing opportunities to transition or maintain economic performance.

Some of the adaptation-oriented actions focused on capacity-building and awareness-raising in the community to recognise climate change impacts (A2, A3). The firms combined financial services, climate information and local knowledge to develop adaptive capabilities at the sites of their operations (A1-A4). Examples included increasing flexibility in the ability to substitute crops for varieties more appropriate to the changing local conditions in Nepal (A9), improving seed quality to adapt to new climate extremes or leveraging savings to finance guarantee funds for restoration after natural hazards in Colombia (A1).

These measures revealed adaptive behaviour in technical and social forms that aimed to improve household and farm resilience. For example, an agribusiness firm (A1) implemented a climate adaptation project with multiple components and resources, that included conservation activities to restore forests and mangroves in cooperation with local cocoa farmers, engagement with an international cocoa agroforestry expert and the development of mechanisms to make technical improvements to the monitoring and control of diseases caused by the rising humidity levels in the fields. These activities helped farmers to achieve "higher incomes and improve[d] living standards," contributed to "improve[d] nutrition and food security," and helped the farmers to "diversify their activities" and "empower communities for active participation in decision making" (A3).

These types of adaptive actions diversified risk and provided local farmers with economic alternatives by reinforcing the production system. The strategies suggest firms enhanced adaptive capacity by improving access to information and offering a combination of material resources for adaptation that stabilised the supply chain, while making parallel contributions to local food security, livelihoods and governance by encouraging local participation in adaptation decision-making. These actions strengthened the surrounding operational environment and created adaptation spaces for the firm and its associates and local stakeholders that accommodated different actors. The central economic agency of individual firms can influence the adaptation trajectories of host communities by supporting adaptation as a social process, with the potential also existing for negative consequences of private sector involvement through competitive or dominant behaviour that hinders cooperation.

In another case (A9), a tea company's strategy assisted tea farmers in coping with climate change by minimising impacts on the local farming system. The factory developed a strategy to support local farms' integration into the international supply chain, provided technical assistance to develop adaptation measures and communicated climate risks to their employees. This project assisted a reported 5609 farmers to cope with climatic changes by minimizing impacts on farming systems.

The firm trained and implemented climate change adaptation measures along four strategic areas: management of pest and diseases, food security, family planning and ecosystem conservation. The information on the family planning strategy was limited in the case study, solely it was reported that this was considered an adaptation option and was widely diffused through local radio stations and a communications campaign. The inclusion of a family planning component to an adaptation strategy deployed by a private sector firm will have underlying moral and ethical dilemmas, as birth control measures will have been integrated on the basis of particular belief system of individuals in the firm.

This type of activity reveals the firm's view of limiting population growth as an adaptation option, which is a prescriptive measure beyond economic and technical solutions to climate impacts. The outcome, value or driver behind the integration of such a component in their adaptation strategy was not clear from their report, but its inclusion is indicative of the potential for firms to promote certain values or beliefs in defining the acceptable or desirable adaptation options for communities.

Two other agricultural firms with supply chains in developing regions (A8, A9) reported similar strategies that shaped local adaptation options. Their approach intended to minimise the dependence of rural households on agriculture for household income by undertaking specific initiatives to address the structural dimensions of development: "economic empowerment of women and community development" (A8). This type of adaptive action sought to enhance local livelihoods through economic security and to promote inclusive gender approaches to widen adaptation spaces for households in host communities. Such approaches are based on sustainable development principles and indicate the type of advanced engagement firms can undertake in communities under climate stress.

Economic calculations associated with both financial and reputational value seem to be drivers of these adaptive actions. The assessment of viable substitutes for crops that had become increasingly risky to grow in a region of changing climate patterns could be one such calculation, as this would allow the firm to shift operations into new markets. In the case of tea farmers (A9), the research demonstrated the viability and profitability of lavender, which can be grown on semi-barren, rain-fed farmlands. This aromatic plant can yield approximately $4,000 US Dollars in yearly profits, with the crop having a 20-year lifetime that demands minimal inputs. It is highly resilient, almost pest-free and cattle have no taste for it, which reduces the potential losses from herds. The firm worked through the local farmers' cooperative to motivate farmers in the increasingly unpredictable climate of Kashmir to switch to this low-risk, high-value aromatic as a strategy for climate change adaptation.

In this case, the firm simultaneously opened new value streams, connected local farmers to the international market and minimised future risks by choosing a crop that can be grown on semi-barren land. The firm deployed its resources to manage climate impacts that affected small growers arising from irregular rain patterns and temperature variations and leveraged the capabilities of the cooperative to engage with the local farmers. The alternatives for the firm could have included shifting production to different crops more suitable for local conditions or reducing crop volumes sourced from this region.

The firm did not report on possible tensions with the local community nor did it indicate opposition to the options presented to the farmers. The absence of reported conflicts and diverging views with local farmers, reflects the firms approach to adaptation, where problems, piloting and experimentation might not have been considered, or co-production processes been part of the adaptation strategy. This suggests that the firms view of preferred adaptation option might have prevailed, and those that complied with the firms desired changes, would have benefited from these changes, while those resisting or choosing alternative forms of adaptation to maintain their livelihoods, might have not remained part of the supply chain. These are the types of changes and decisions, that might not directly lead to forced forms of transformation, erode the local systems ability to cope with future changes by selecting efficiency and economic performance as indicators of adaptation.

The substitution of these crops aligned with internal business drivers and implementation of the adaptation strategy was presented as consistent with adaptation activities but understanding the information exchanges and allocation of resources necessary to shift the communities' economic activities is critical to understanding how adaptation processes are shaped by economic agency. The cooperative played a key role in interpreting complex technical information from the firm to farmers by facilitating the participation of individual farmers in decision-making and sharing knowledge on farmers' available options and the potential benefits of the new crops. The cooperative's own business model is built on the involvement of multiple farmers, which allows the cooperative to undertake risks calculations beyond the capabilities of individual farmers.

This example illustrates the influence of an individual firm in shaping adaptation options at the local level where culturally and historically established practices are changed in response to adaptation opportunities presented by the firm to the local farmers. The firm's reliance on local groups to provide access and complementary knowledge to implement the adaptation plan indicated that the planting of alternative crops and deployment of technical solutions to raise efficiency at the farm level are preferred as adaptive actions to reconfiguring the supply chain to incorporate farmers from different locations with more stable climates. The firm under climate stress recognised that investing in substitute crops to reach new markets was a way to undertake adaptation and reconfigure its business model to align possible sources of financial value with its cost structure. This required improvement in local capacity to overcome losses experienced during previous harvests and the promotion of alternative mechanisms for local farmers to protect their livelihoods from climate change risks and impacts.

Operational actions are part of strategic adaptation plans, but strategic actions require the shifting, adjustment or deployment of a combination of multiple resources to influence specific locations or sites of operations. In the agricultural sector, the nature of the firm's supply chain results in any adjustments to operational routines affecting external associates and stakeholders. For example, in reporting on their adaptation projects, agricultural firms (A3, A4) in Uganda and Nicaragua described increasing monitoring activities to identify recurring crop and human disease resulting from changing climate impacts. These monitoring actions were driven by the search for stability in the firms' production routines and supply chains but can ultimately lead to improvements in those farmers' part of the supply chain levels of efficiency and health. These types of benefits and contributions, will again depend on several factors including compliance with the firms desired forms of adaptation, as mentioned in the previous section.

Improved health outcomes were also associated with adaptive actions by cocoa firms (A1, FB2), which were designed to support local farmers involved in their crop harvests and their families. The firms focused on anticipating disease within local households and working closely with the farmers to supress possible crop disease from rising levels of humidity and heat. These activities are not framed as corporate social responsibility; they were driven by core business components that required sourcing raw materials from specific locations to generate value.

Firms furthermore incorporated technological tools and precision methods, such as hydroponic and organic production (A4, A6), in their adaptation efforts. The configuration of the firms' relationships in specific geographic locations is key to their business model, both as a source of value for the firm and as a mechanism to invest and draw resources from their associates. In these cases, small family farms and medium firms are the most common supply sources.

These farmers and households are the main beneficiaries of most firms' adaptation initiatives along supply chains in Colombia, India, Kashmir, Nicaragua, (A1, A8, A9, A3, A2), and of firms working in partnership with coffee growers in Mexico, Peru, Kenya, Tanzania and Uganda (A2, A3) to widen the scope of their adaptation. The firms sourced different crops from farms located in regions with diverse climates to maintain continuous operations and their market competitiveness.

The reported adaptation projects in those geographic locations experienced similar climate-related impacts: extreme heat, flooding, irregular or off-season rainfall patterns and the growing presence of pests from changing climate conditions. The adaptive actions in these circumstances can be understood as means-to-end chains where the intended outcomes are linked to the firms' core operations through business model sub-components like logistics, production, processing and sales.

These firms reported undertaking a variety of adaptation actions, including raising awareness or establishing guarantee funds to enhance resilience of the broader community to climate impacts, with effects at the household, local and regional levels (A1-A9, FB1-FB9). Financial firms' strategic actions complement these actions through pricing and managing climate-related risks. This can help farmers and tourism firms cope with catastrophic losses from hurricanes, coastal development damages and personal or commercial losses from extreme weather or climate events that impact their financial operations (F1, F15, F14). Taken together, these actions indicate strategic shifts in business model parameters through the reclassification of risk based on expected climate change impacts, which also leads to new opportunities for the firm. This reclassification changes the business model of a firm, transitioning it from one cost-value structure to another driven by the recognition of shifts in the external environment.

4.2.3 Experimental, Science and Technology Adaptive Actions

Experimental, scientific, and technological adaptive actions can include trials to minimise climate impacts on crops (FB8), pilot attempts of future investments (F5), knowledge generation among farmers (FB2, FB6) and research to improve agricultural practices (FB5) or expand biodiversity and ecosystem conservation (F1, F2, F6). It also includes the reported efforts to raise public awareness on potential climate impacts and natural hazards, such as targeted provision of training for farmers to develop optimal responses to climate impacts.

Experimental actions combine the capacity and knowledge of multiple sectors; agricultural firms, for example, may work closely with ICTs to generate field data to make strategic decisions for managing or planning operations. Local learning and knowledge processes are likely to occur among community actors that jointly pilot different approaches to manage climate-related risks, as would happen in the previous example when ICTs introduce new information to economic assemblages. Support services could be expert guidance to improve farming and animal husbandry techniques (I2), the diffusion of climate resilient technologies to boost local income (I2), the distribution of software tools for local consultancy firms to model ground applications of infrastructure (I4) or the dissemination of climate forecasting data and severe weather warning alerts among farms in local communities (I7). The actions that featured the support of ICT firms were reported as benefiting individuals and communities, such as the reported 90,000 farmers in Ghana that have gained access to low-cost weather monitoring information relayed by an ICT firm (I7).

Firms undertaking these adaptation actions actively recognised mapping and prioritising information, curating data to improve decision flows, identifying blockages and barriers, and experimenting with different approaches to generate useful data that can be integrated into business routines and practices in a timely and actionable manner (I8) as critical. These firms reported on the need to provide accurate, timely and user-friendly data along the various paths where information flows. The careful curation of information for adaptation suggests that it enables local actors to act, improve response time and harmonise communications among individuals, groups or organisations with different levels of capacity. These are critical functions to develop capabilities and enhance social approaches to adaptation.

In the energy sector, there is evidence on the integration of technology in decision-making, such as GIS techniques, 3D modelling to examine converging variables across time and space (E4) and consultation with experts to map potential changes in climate that could result in physical impacts on firms. These practices demonstrated the consideration of both physical variables and economic calculations in planning future activities of the firm (E5). The scoping studies correlated each identified risk with the firms' assets or operations to identify threats necessitating response and adaptation. This indicates that bio-physical variables can be linked to components of a firm's business model by unpacking and tracking impacts to internal elements of the organisation where their potential disruptions to business routines are recognised. The specificity of the connections provided a unique example of the integration of external changes into the firm's internal architecture where adaptation planning considered configurations and processes of the business model.

Climate science and technology tools allow firms to predict climate-related impacts and determine investment levels, providing the foresight to undertake deliberate and anticipatory adaptive measures. For example, in the energy sector, a technological platform anticipated climate variation that could potentially affect power grids, which supported the adoption of pro-active solutions, minimising interruptions to energy transmission and distribution (E4, E5). These resources in themselves do not provide firms with the ability to recognise or use information; expertise and technical capacity are required to codify and integrate the generated information into business processes. For example, in the case of GIS, a firm (E5) in the energy sector "hired consultants to use GIS to map potential changes in climate and physical effects to the company's service area and other areas where it has large scale investments," and used the results for "modelling impacts and development of robust strategies to reduce overall cost of adaptation and minimize operational disruptions."

These different tools allowed firms to conceptualise risk in relation to their business model and identify areas for adaptation planning and strategic investments. This was also illustrated in the Brazil case, where an energy firm developed a tool using the new concept of “grid,” which enables space-time horizons and information about climate and environmental variables to converge (E4), providing the firm with a "3D" vision based on their own business model parameters. Conceptualising and visualising the firm’s cost, value and operational processes in this way allowed the integration and normalisation of adaptation planning into their structure.

In the financial sector, science- and information-based resources improve business practices by relaying weather information, climate risk assessments and research programs. Access to such data suggests the potential of these firms to amplify and diffuse critical climate information codified in formats understandable for local stakeholders (F1-F14). For example, know-how and product development capabilities have widened the use of private sector risk financing methods for adaptation to climate change and assisted in stabilising Thailand’s agriculture and economy (F11). Levels of specificity have been able to be adjusted in business calculations so that insurance pays out a pre-stipulated amount if certain conditions are met against indexes for temperature, wind speed, precipitation, snow depth or other weather-related indices (F11).

In the ICT sector, firms engaged with municipal authorities and local businesses to expand local services, which can improve coordination among different sectors. With the automation of water provision and quality monitoring for aquaculture, conservation and local hydrographical data (I2), for example, the codification and relaying of information helped to develop risk management and support local decision-making that was critical to protecting ecosystems or enhancing food and energy security at various levels (I3). The potential for technology to inform decision making is dependent on the ability to combine technological resources with local capabilities at specific points or locations. The firms in the ICT sector are expanding business models through pilot projects, suggesting that their climate adaptation-oriented work will expand to the extent that these experiments yield large impacts by empowering local partners and associates (I6). ICT firms recognised that adaptation requires business model innovation, which explains why these types of firms have been the pioneers in the technology sector in adjusting business configurations to a rapidly changing landscape that can be replicated in different locations.

4.2.4 Cooperative Adaptive Actions

There is a notable example of competitor firms engaging in sectorial adaptation strategies using a regional approach that connects multiple local assemblages. In in the case of the Scotch Whisky (FB5), impacts threatened entire historic economic assemblages, which prompted firms to collectively undertake strategic adaptive actions. In the Highlands of Scotland, raw materials and spirits are commonly exchanged among competitor firms to develop new products. Unlike firms in other industries, distillery firms in this region cannot relocate to maintain or preserve operations from climate impacts due to the intrinsic value of this geographic location to their production given its legal, cultural and historical legacies. The maturation time of the products being a source of value for firms in the distilling industry prompts long-range investment planning to strategically protect critical assets, similar to its importance for firms in the energy and construction sector to sustain operational capabilities. For distilleries, however, additional calculations are needed based on their close interdependence with agriculture, which is a higher climate risk sector.

Undertaking adaptive action within these closely-bound supply systems located in unique geographic locations requires firms to invest in knowledge generation and information sharing, even with competitor firms, in order to sustain system functions and stabilise production cycles under climate stress. As a result, workshops to raise awareness of climate change impacts, information sharing and research and development to generate new ideas for building adaptive capacity (FB5) were reported as core components of adaptive actions. These types of adaptive actions revealed the nature of the economic assemblage in vulnerable regions and, more precisely, the collective approach to adaptation that firms had adopted. For example, the Scotch Whisky distilleries, reported acting collectively as a sector to undertake adaptation actions to tackle impacts of climate change (FB5) and mobilising knowledge to understand and act on climate change risks by sharing production information and best practices, which helped to generate ideas and build adaptive capacity at the industry level (FB5). The impact of climate stress on common production inputs and locations revealed vulnerabilities and led to production disruptions and cost increases across the entire industry. A collective approach to adaptation was pursued as a result.

Other instances of cooperative actions were seen among financial firms. These firms provided services and investment options to businesses undertaking a variety of climate change mitigation activities: sustainable energy investments, new technologies, green processes, CO2 emission schemes (including carbon trading) and the conversion of equipment to improve energy efficiency in the private sector. This sector reported a wide range of partnership mechanisms to cooperate and support adaptive actions at individual scales. They leveraged complementary resources and provided expertise necessary to develop the financial capacities of mid-range firms in regions facing high climate and disaster risks. Such actions shifted organisational structures of the firm that now accounted for extreme climate events with a great degree of specificity, which may become useful for other industries needing to understand and distinguish climate adaptation risks.

In climate change adaptation, financial firms reported providing services through partnership agreements and studies into vulnerability and risks. The financial sector reported activities that suggested explorative approaches were being used to understand the potential impacts of climate change on clients' business operations and to expand opportunities for economic investment through a growing market of climate adaptation financial services. This sector's actions indicated a planned and gradual approach to incorporating climate adaptation actions into their existing business models. These firms have sought opportunities emerging from the uncertainty created by climate extremes, including undertaking strategic assessments of potential business risks and costs for their investments (F5, F8). In this sector, the partnership mechanism facilitated finance firms to reach individuals and provide risk management resources for adaptation by working with international development donors (F7) that leveraged financial capital to provide catastrophe insurance to 55,000 microloan clients. This approach made use of a combination of resources and its related learning activities, such as education programs on individual risk reduction and natural disaster awareness, demonstrated innovative ways to advance the climate adaptation agenda.

Cooperative actions imply information sharing and a potential for the broader reach of climate adaptation knowledge. For example, in the finance sector, a firm disseminated the findings of a climate risk report to a target group of 35 thought leaders in order to identify critical adaptation issues in their respective areas of expertise (F9). This type of cooperative action indicates the existence of a practice-knowledge assemblage that broadens the scope of adaptive actions in each geographical location and facilitates partnerships by alerting to local climate risks. Similarly, research partnerships, like the one between HSBC and UK Met office, help provide clients with more accurate assessments of the risks and impacts climate change presents across their investment portfolios (F7). Partnerships have also allowed financial firms to provide support and technical expertise to organisations implementing community-level agricultural projects to reduce risk and build climate resilience by improving soil management and irrigation (F12).

In the consultancy sector, some firms (Cs3, Cs4, Cs6) utilised partnerships to contribute to developing local adaptive capacity. They established links to local professional associations in their technical sector of expertise and leveraged external resources to further their knowledge in ways that complemented their services, such as examining the economics of adaptation to determine risks calculations (Cs6). Technical briefing notes on adaptation to local firms and experts, such as legal briefings for the local legal community, helped to diffuse the information learned (Cs1). Another firm in the consultancy sector demonstrated cooperative action through the establishment of water user associations (Cs7). This facilitated the direct inclusion of these groups in processes to shape local water use governance mechanisms, seeking to improve water management in response to shifting rainfall patterns that depleted resources. The firms also adopted flood warning technologies, like remote sensing, hydrologic models, and geographic information, to provide early warning at the village level, which suggests that firms' cooperation with local partners can trigger the active involvement of different actor's part of a social assemblage in adaptation processes.

4.2.5 Prescriptive Adaptive Actions

Prescriptive actions were identified as being directed towards peer firms or the broader community. The peer-directed actions focused on codifying and relaying technical information to improve local capacities, and those oriented towards the broader community revealed value-based recommendations on adaptation options. Firms in the agriculture, consultancy, finance, energy and tourism sectors reported minor prescriptive actions intended to raise awareness of climate risks (A1, A2, E1, F3, I1T1), such as industry workshops on climate change impacts and adaptation options, and resource conservation actions. In the consultancy sector, firms deployed expert knowledge (Cs2) to codify climate information for specific audiences, building critical adaptive capacity and facilitating knowledge exchanges. These firms engaged in the development of legal frameworks that complied with emerging adaptation measures, policies and regulations to diffuse and unpack adaptation at the local level (Cs1), paying particular attention to policy frameworks and regulations that inform decision-making and influence governance arrangements between firms and local actors. The associates reported in firm adaptation reports were consistent with efforts to create knowledge and disseminate information, including engagement with local firms in similar areas of work, such as legal and tax accounting. These are critical areas for developing capacity, as their work enhances understanding of and compliance with emerging climate regulation, while the actions also facilitate the creation of policy incentives to undertake adaptation measures.

The actions of these firms in engaging to shape regulation and policy though dialogue, lobbying or participation in public working groups have been identified as drivers of adaptation. For example, international consultancy firms worked closely with local consultancy associations to disseminate and diffuse funding mechanisms and financial accounting for adaptation projects. This occurred through dialogue and the analysis of firm liability (Cs1, Cs4, Cs5). The codification of new information into operational language was evident in work to disseminate knowledge through professional briefs to inform the legal community of legal components of adaptation, technical information on climate science, business continuity reports and property protection codes (Cs1, Cs4, Cs5). In this sector, the feedback mechanisms suggested firms' ability to learn from local experience and customise capacity-building work according to guild member's preferences (Cs1), which provided specific assessments on current vulnerability to extreme weather events.

Other prescriptive actions were more formal and structured, such as the certification of adaptation specialists. This suggested that firms recognised emerging professional positions across industries and used this knowledge to build expertise on climate issues, introducing programs like the professional certification through an 'Adaptation Academy' and advisory services (Cs4). These types of consultancy firms focused on the development of new services and tools for firms in other industries as financial firms had but focused on knowledge translation and the diffusion of technical information to increase capacity. These innovators and early adopters perform a key role in diffusing knowledge that can trigger the integration of adaptation design and planning into advisory services. This can further lead to business model innovations by configuring new value creation mechanisms based on adaptation services.

4.2.6 Policy Engagement Adaptive Actions

Policy engagement by the construction sector has helped to develop local policy. Firms reported working with local and State authorities to establish minimum compliance requirements within local regulations and participating in public-private partnerships, as these are the normal investment vehicles for larger infrastructure projects such as roads, bridges and urban infrastructure. These types of projects increasingly require any proposed new investments and urban policies to consider climate adaptation. Policy adaptive actions reported included collaborative studies to investigate the impact of climate change on highway policy and standards to identify adaptation opportunities (Co8) and gathering evidence from past damages on city infrastructure (Co7). These collaborations between the firm and governments, with the latter as beneficiaries of the adaptation initiatives, provided a comparative advantage to firms involved in regard to their competitors, and also into their ability to position themselves in direct consultation with governments, as they could integrate technical understanding of climate-related risks in planning new projects (Co1, Co 3, Co4, Co6, Co7, Co8). The integration of adaptation into construction firms' business models is illustrated by the changes in design, planning and economic calculations for additional technical elements informing operations and business strategies.

In the agriculture sector, further evidence of policy engagements suggests individual firms can have influence at regional and sectoral levels on adaptation planning. For example, an organic firm (A4) participated in a regional project on climate change adaptation in the corporate sector. During the project, the firm worked with local government offices to analyse and identify climate risks and adaptations in their region, which benefited the firm itself, policy development and other companies that engaged in the policy discussion. In these discussions, the future commitments of the private sector in local adaptation processes can be shaped by the firms themselves as they use their expertise to inform regulation and policy. The engagement of individual firms in adaptation policy formulation indicated the potential for economic assemblages under climate stress to shape the incentives used to actively engage the private sector on adaptation. These forms of engagements, provide unique access to firms to materialize their views on adaptation through policy processes, and potentially lead to co-optation of the spaces to decide on the desired adaptation strategies. This raises a potential issue of conflict of interests and lack of transparency in allowing certain actors access to policy discussions that don't account for good forms of governance.

4.2.7 Transformative Adaptive Actions

The transformational type of adaptive actions represents potential desirable forms of change. An example was identified in the reports, as a partnership originally formed to test communication technologies became an independent, non-profit organisation that provided adaptation services (I3). This highlighted the capacity of partnerships to introduce new information into organisations and illustrated an example of shifting business models. This extreme form of reconfiguration changed the internal operational architecture of an organisation as its mandate changed to align with adaptation objectives. The emergent entity's business model integrated adaptation strategy as a core component of its configuration, triggered by the identification of opportunities and widening space for adaptation business services.

The data analysed in the case studies, has been self-selected by firms and only allows to infer possible transformation level changes within the firm, as these were reported. To report on transformational types of changes in the external context or among other actors due to the firm's adaptation actions, would require a more dedicated research report or monitoring and evaluation documents form their adaptation projects. This was a gap in the data, and this cannot be presented with the current data, however, it provided information to develop hypothesis of where transformation changes might occur from the different types of adaptation actions and resources being deployed by firms. A further analysis of transformation will be presented in the empirical chapters with data collected through field work.

4.3 Actions and Actors: Adaptation in assemblages

The assemblages of actions, actors and resources identified through the case studies provided an overview of the types of economic relationships undergoing climate stress in different economic sectors and geographic. The rationale that connected adaptive actions to individual associates or stakeholders was consistent with the three levels of business model activity: *financial, strategic and operational*. This firm-centric view of adaptation was expanded to the relational perspective of adaptation by further developing the concept of adaptation actions in the private sector using specific examples of connections between the business model and locality. The analysis revealed the components of different assemblages necessary for local adaptation, such as specific technologies, forms of information, processes and targeted investments, partnerships and innovations informing adaptation planning and its integration into business models. The responses indicated that the creation of adaptation space for the firm – and for individuals, local groups or organisations in some cases – benefited from the extension of business models to recognise relationships to different elements of communities.

The evidence suggested that firms will align and deploy resources in accordance with their views of what constitutes desirable or possible adaptation options. The case studies also open questions, however, about underlying tensions and contestations that could have occurred between those actors affected or limited in their adaptation options by the firm's changes or actions, particularly when the firm's adaptation choices result in uneven allocation of resources or investments to stabilise operations or access new markets; when the firm limits access to information to exclude certain actors; or when the firm's actions obscure decision-making at the smaller scales of the assemblages by closing adaptation avenues. These aspects are at the core of the following chapters, which draw on fieldwork data to expand the analysis and directly examine the relationships and trade-offs within the assemblage themselves.

4.3.1 Internal Assemblage – Organisational adaptation

These adaptive actions shifted organisational business routines and reshaped business configurations in response to climate stimuli or market opportunities in the widening area of adaptation services. The changes modified the locations of operations, improved processes or led the firm to develop strategies to protect critical economic functions from extreme climate or disaster impacts. These actions created adaptation space for the firm by enhancing its adaptive capacity through the protection of critical assets, climate proofing of infrastructure, integration of climate information, acquisition of resources or leveraging of external capabilities of other actors to improve or maintain business operations affected by climate change impacts.

Expanding the business model and organisational adaptation space enhanced firms' ability to accumulate capital and develop dynamic capabilities to operate in complex operational scenarios under climate stress. For example, patenting climate-resistant seeds created by the firm would provide additional financial resources in the future (A1, A4) by allowing the firm to grow crops where no other firms can, differentiating them from their competitors or the sale of the seeds on the market. The seedbank's financial value provides firms with the ability to maintain or extend their market share. The accumulation of these types of resources as anticipatory adaptation measures increased the resource base available to the firm in a virtuous spiral of adaptation and investment. As larger firms undertake these forms of anticipatory measures, their actions may open or close adaptation pathways for smaller farmers or suppliers operating in the same locations. Climate-resistant seeds could become substitutes for current seeds or for other crop varieties that are increasingly complex for local farmers to grow, thereby minimising climate risk on their agricultural routines. However, these actions might also limit small farmers, cooperatives or associate firms' adaptation options, if the focal firms decided to limit the use of proprietary seeds to specific or high-performing clients of the firm.

These adaptation choices by the firm can lock small farmers into a form of a private adaptation regime where established business drivers, such as bottom-line profits, can dominate economic decisions central to these adaptive actions. This could potentially undermine direct associates' capacities by creating trade-offs that originate in seemingly unrelated organisational decisions according to a pre-set business model. The firm-centred views of adaptation are limited to economic considerations and maximising shareholder value, and while some of these actions, such as expanding market opportunities, are critical for organisations to develop adaptive capacity, they might be cost-prohibitive for other actors in their assemblage with development shortcomings without access to the resources or information necessary for identifying or pursing adaptation best adaptive options. Under this scenario, focal firms become the sole suppliers of material resources, expertise or information to accommodate local adaptation preferences. Some larger firms have recognised a wider view of climate risks and begun to explore the potential opportunities to invest in adaptation aligning their activities and key actors in the assemblages with future market opportunities.

A firm's decision to configure its business model based on sources of value from patent revenues or stable production can determine the extent of its openness to sharing information that is critical smaller actors like family farms, clients in the construction sector, tourism agencies or insurance companies when undertaking operational adjustments or investments necessary to cope with emerging climate impacts. In industries with limited stakeholders, adaptation projects can be interpreted as financial ventures for the organisation, where the firm develops products or services based on their potential market value, and communication or cooperation becomes a desirable form of engagement to realise potential financial gains. In other sectors, competition and resources can dictate the most desirable forms of action, which may be in opposition to a social process of adaptation and could even undermine the efforts of local actors to find new resources or create knowledge necessary to develop foresight and take anticipatory adaptation measures with broader benefit.

The adaptive actions that focused on developing products and market value originated from the recognition of opportunities opened by climate change and allowed firms to expand their market share, gain a competitive advantage or leverage resources by accessing public financing for adaptation. However, those adaptive actions linked to research, climate science, local development, pilot projects and adaptation partnerships revealed value that expanded the business model based on consideration of social adaptation needs. For example, in the chemical sector, the existence of patent rights led to the creation of new products that generated high value for the firm and illustrated the types of actions of business firms investing and recognising value from adaptation. They sought to develop innovative and future-focused products (C3, C4) and drought-tolerant corn technology (C1, C2) through biotechnology investments by multinational firms.

The products targeted markets as part of a multi-generational family of biotech drought-tolerant products expected to be available on the market during the next decade. Patent rights over this type of technology and other products could lead to the individual firm's economic interests shaping local adaptation possibilities and may limit prospects for equitable adaptation. Licencing restrictions may also be imposed with such technologies, like genetically modified crops in the agricultural sector. The relational view of adaptation would require the firms to work with local partners to develop new seeds or find value-sharing mechanisms to protect local assemblages from becoming private adaptation regimes as a result of the introduction of an element that skews the adaptation trajectory towards purely economic calculations.

Adaptation to protect critical firm functions was illustrated in the cases where firms developed long-term, strategic adaptation plans after experiencing direct, recurring losses as a result of climate impacts and determining that the cost of inaction was greater than the cost of investing at the present time. For example, longer-range plans reported by energy firms (E1) included assessments and research into the potential impacts and solutions of heightened disaster risk, embedding climate adaptation considerations into business routines in the process and seeking 'hard' adaptation measures. These firms then worked to protect critical assets such as data centres, transmission towers and business hubs from disaster risks (E5), creating redundancy in data storage throughout the service area. In this sector, adaptation projects adjusted business models to local geographies and expected climate risks in operational regions. This finding confirmed that firms with longer-range planning capacities employ scientific data and technology in decision-making, reflected in the investments made to expand core capabilities.

A systematic approach to adaptation planning was not observed in other economic sectors. It was found that responsive or reactive adaptation actions are more common in managing existing climate impacts, which creates the potential for maladaptive outcomes as adaptive measures are based on existing business models that do not account for adaptation planning in their decision-making processes.

4.3.2 External Assemblage –Associates and Stakeholders

Firm's direct contributions to the adaptive capacities of their associates or stakeholders overlapped with adaptive responses that sought to improve organisational adaptation capacity. In fact, these actions were observed in the data as the consequences of internal shifts or reconfigurations of business routines to maintain or expand capabilities in response to climate threats or disruptions. These actions took the form of technical improvements to reduce losses that created risk for core functions of the firm or production systems and the deployment of expertise to develop capacity or improve technical skills, as well as corrective measures to solve problems resulting from climate impacts. Adaptive actions included technology transfers to associates, like irrigation measures or weather monitoring antennas, and information sharing among a wider variety of stakeholders, such as local government or even competitor firms in some cases. These were calculated actions that enhanced the future ability of the firm to maintain operational capability in regions of high climate risk.

Deployments of technical expertise improved the efficiency and capacity of the firm's suppliers or direct stakeholders and extended the firm's reach, as advice shaped local policy or regulation in disaster risk and climate change adaptation. This was evident in the cases of cocoa farmers or organic agriculture (A1-A9) and construction to improve climate compatible infrastructure regulations (Co1-Co5). These activities had an expanded influence on policy and regulations through the development of tools for municipal governments to better assess the vulnerabilities to climate change and prioritise their investment in the modernisation of municipal infrastructure (F9).

Different cooperation mechanisms, such as formal partnerships, were identified, as firms recognised risks and opportunities and shared financial resources or information related to adaptation with other firms, including competitor companies as in the case of Scotch Whisky. These actions indicated the potential for firms to engage in policy discussions through relational connections with local and regional governments. The potential to broaden collaboration in the context of adaptation signals to laggards or late adopters of adaptation actions that coordination provided a way for similar actors to recognise the challenges of climate impacts on regional production systems. In communities or assemblages anchored to the economic and operational configurations of a single firm, firms can have a significant impact on local adaptation and development gains. The spatial influence of firms in determining these pathways, which are shaped by the firms' economic priorities, can directly create adaptation options that align with business priorities or potentially precipitate maladaptive processes in small regions. The potential of individual firms to enhance or amplify positive adaptive outcomes is higher in communities with strong economic and social dependence on large firms.

Some approaches to developing adaptation capacity, such as international carbon trading and climate change finance schemes (A2, A3), were reported in these case studies. The business models expanded interactions to an assemblage of suppliers that combined the work of multiple firms and innovated all firms' business models by introducing financial mechanisms to sustain forms of adaptation. The role of the focal firm was clear in funnelling information on carbon trading systems into local food production systems, where the function of the firm as an early adopter and diffuser was defined by these actions in parallel with the creation of financial value. The firm secured adaptation resources for local farmers to stabilise their sources of raw materials and created a new assemblage of farmers that were protected by insurance and had access to markets that provided additional resources through carbon trading.

These actions expand the adaptation space of economic assemblages closely linked to the firm and its associates through the exchange of resources, information and technologies. When firms in the agriculture and food sectors acted to enhance food security, these measures contributed to the ability of employees' and suppliers' households to compensate for climate-related income losses and provided alternatives mechanisms to protect historically accumulated assets or resources necessary to maintain the wellbeing of farming families (A1-A3). This demonstrated the concrete contribution of individual firms to stabilising the economic or social assemblages in host communities after poor agricultural cycles.

These actions created social licence and value for the firm by protecting their assets and capabilities and providing the necessary economic support to maintain a viable supply chain for the next agricultural cycle. These contributions to downstream associates are critical to preserving social and economic relationships within the local community, building adaptive capacity and communicating adaptive actions among the assemblage. The causality cannot be directly attributable to the firm's deployment of resources; however, they contribute to introducing information and enabling feedback loops for local knowledge, as in the case of consultancy service firms that trained local firms in legal or financial aspects of adaptation-related investing or business planning to develop their capacity (Cs1-Cs5). These projects indicated a coherent approach among firms in the same type of consulting services but operating at different scales from the international to the local level. These are different forms of knowledge assemblages than those within the economic assemblages of suppliers, where information and knowledge are linked to economic cooperation. In the consultancy relationships, the exchanges contributed to the diffusion of emerging concepts and knowledge of adaptation to improve frameworks and tools that support adaptation processes involving diverse actors across industries.

These cases highlighted firms' potential to disseminate information by mobilising established business models to reach associates and indirect stakeholders. The firms that incorporated climate adaptation planning into new business routines communicated novel information to different local actors through new services, targeted sharing to a specialised audience and through partnerships. These firms acted as knowledge brokers, which could support or trigger learning processes among a variety of key stakeholders clustered in regional economic assemblages. This can become an avenue to facilitate adaptation where competing firms in similar industries access or share information in a spaced designed to facilitate learning and connections among business drivers shaping adaptation in specific locations.

4.3.4 External Assemblage – Indirect or Undetermined Stakeholders

These adaptation actions are those identified as "no regrets" adaptation that contributed to building the capacity of indirect or undetermined beneficiaries. The benefits may be diffused in space or time without being clearly attributable to the origin of the resources or yielding direct benefits to the firm that deployed the resources. These actions indicated that contributions were driven by considerations beyond the firm's business model economic calculations were profit maximising is the main driver of the firm's behaviour and suggests more cooperative actions manifested in the collaborations with external actors, including competitor firms. For example, a firm established a guarantee fund in partnership with a financial institution to protect farmers from anticipated losses due to natural hazards or climate impacts on crop production (A1-A4, F1, F4, F5, F7). The funds enrolled farmers who were part of the supply chains but will protect undetermined farmers who are deemed eligible to participate in the guarantee program in the future.

Assemblage-wide contributions can be necessary to maintain operational or production functions in communities. Beyond finance mechanisms, these require investments in ecosystem restoration, communication technologies to facilitated greater awareness of climate risk by wider audiences and the provision of technical services to local firms, including those in sectors such as tourism, transport and construction. Adaptation actions taken to regenerate ecosystems, for example, have contributed to the development of measures that protect against identified climate impacts from flooding or land erosion by substituting or reinforcing infrastructure.

These actions were reported as multi-organisation investment projects led by a private sector firm, which created an opportunity to experiment with and test adaptation strategies previously ignored. In another case, a chemical company undertook a regeneration project driven by an interest to lower the cost of protecting critical assets; at the same time, the firm collaborated with a local academic institution, engaged local government and restored a local wetland eco-system (C2). In the information technology sector (I3), firms provided services for adaptation and developed partnerships in the process. A telecommunications company and farming firm formed a partnership that transformed into a new non-profit entity that provides climate information services for farmers in the region. The new organisation configured their business model by integrating climate adaptation services as its core function.

These forms of engagement were demonstrated in the data, which indicated the potential for firms to enhance and amplify information and resources to provide a series of climate adaptation services in locations under climate stress. Partnerships facilitated these actions, which may indicate their utility as vehicles for introducing new information and triggering learning within organisations themselves, allowing for business model innovation that accounts for adaptation planning in the future.

Conclusions

In this chapter, a preliminary outline of different socio-economic assemblages was established, first by examining the types of actors associated to focal firms, and secondly by characterising different forms of adaptation actions. The data suggested that private sector, for-profit firms can facilitate adaptation through the deployment of financial resources, technical capabilities or technical skills, but have pursued adaptation to conform with their current economic functions. While these organisations drive innovation, they also represent and enact a capitalist economic model, which has contributed to inequality and rapid environmental change. In their continuous search for expanding economic gains and capital investments to expand financial value, there is the potential that private sector resources might continue to construct a zero-sum context derived from increasing climate impacts.

The breadth of activities and scales of action reported in the cases, provided a technical understanding of adaptation actions unique to individual firms, where precise calculations to integrate bio-physical and social components at different stages of adaptation planning serve the economic interests of individual firms. This approach is a technocratic search for efficiency, critical for the firm's performance under climate stress and demonstrated ways in which firms combined resources to widen adaptation capacities for the firm by focusing on external actors beyond the organizational boundaries.

The firm's actions suggest incremental adjustments, based on technical solutions or efficiency increases, but remain devoid of any form of deliberate transformational efforts aimed at developing adaptive capacities in host communities, more specifically, they indicated introduction of new forms of self-selecting behavior which could create tension among communities in competition for resources necessary to cope with increasing climate impacts.

In the future, institutional and social factors might pressure firms to reorganize their adaptation responses in accordance to social preferences, or political drivers, such as trade-offs negotiated in the role of the state and private actor in enhancing local resilience. The evidence provided by the firms doesn't account for underlying power relationships and failures in adaptation projects. A missing component are descriptions and accounts of contrasting views of adaptation, where individuals, groups or communities might seek adaptation options beyond the economic drivers and technical solutions and be willing to accept shorter term trade-offs for longer term adaptation options, which might be paramount to creating common adaptation space, and where different value and knowledge systems might be have opposing preferences for adaptation pathways. While firms stabilise economic functions through incremental adjustments, tipping points and local thresholds for adaptation will render incremental change insufficient to maintain current conditions in these assemblages. In fact, their current actions have already begun to construct pathways that can lead the different actors along adaptation trajectories preferred by the firms, both by narrowing the financial resources or establishing barriers to knowledge exchanges or making decisions on behalf of different actors in these communities. The firms do not have complete control or responsibility over adaptation, and development failures, but there is an interest in their pursuit of profits to engage in a particular form of climate change adaptation. These included minor corrections that assured new financial options, social license to operate or opening new markets for their products and services, which themselves provide alternatives and sources of additional information necessary for adaptation. The cases in the past section also have provided the different scales of potential transformation, which will be further explained and analysed in the following empirical chapters. This itself is a contribution to understand transformation, as deliberate changes in response to climate impacts, but also as forced changes emerging from the conditions created by technical and financial adaptation measures of dominant economic actors in a particular assemblage at the community level.

CHAPTER V

Business models, Adaptive Actions and Adaptive Capacity

Introduction

This chapter expands the analysis of adaptation in the private sector as assemblages by presenting evidence collected during field research in various geographic locations, were different focal firms and their supply chains operate. The two first assemblages, are located in San Jose del Cabo, Baja California Sur and Ensenada, Baja California, Mexico, and Santa Cruz, California themselves connected as a single meta-supply system; the third assemblage is located in the Highlands of Scotland, United Kingdom.

It is necessary to first establish the types of climate associated impacts and stressors, to understand the linkages to the different elements of the business model and map the types of actions contributing to adaptation within the assemblage. The first section of the chapter, will establish the different types of climate stressors, informed by scientific assessments, policy reports and complemented by the observations of local farmers, directors of the cooperative and firm employees.

The analysis the will focus on a firm-centric organizational model in the agriculture and food and beverage sectors and expands to examine a variety of the firms' relationships with their associates, such as farmers and farming cooperatives, and other local stakeholders like local government, funding institutions and research centres. These exchanges are studied to understand how? and why? resources and information necessary for adaptation are exchanged, diffused or arrested by the firm.

The relational view of the different economic and social relationships through sets of adaptive actions is described as means-to-end chains in response to climate and disaster events, where these processes indicated forms of business model configurations and changes shaping the ability of individuals or groups to undertake deliberate adaptive actions or decide on specific adaptation trajectories.

The first assemblage is integrated by a firm based in Santa Cruz, California, in the United States, and a supply chain of farmers extending from Santa Cruz to hundreds of independent farmers and a farming cooperative in the communities of San Jose del Cabo and Ensenada in Baja California, Mexico. The second assemblage, is integrated by a firm and its suppliers located on the Black Isle peninsula in the Highlands of Scotland in the United Kingdom, were the focal firm is a distillery, a malting firm, and a farmer's cooperative with over 70 active members.

In each case, agricultural production assemblages include different size farms from small family farms to medium-sized firms, operating at various local, regional and international scales. The assemblages in different geographic locations, also considered the material resources critical for production deployed and used by the firm, employees and their associates, resulting in new assets, knowledge and information necessary for adaptation. For example, irrigation and storage infrastructure, precision technology to measure temperature or test moisture, and many types of expertise, labour and forms of information. The combination of these elements achieved a desired economic function, but also revealed the linkages between components of the business model and adaptive capacities that constituted an assemblage.

The first section of this chapter describes the types of climate-related business disruptions experienced and establishes the connection between adaptive actions reported or observed during fieldwork and the development of different dimensions of the firms' adaptive capacities. The second section expands the analysis outwards along the firms' relationships with members of the assemblage in the boundary of their operations, defined by direct observation and semi-structured interviews, which provided insights into knowledge sharing and learning activities, adoption and diffusion of innovations and various forms of cooperation and co-production between members of the assemblage critical for adaptation.

The focal firms have their business model configured around a specific supply chain of farmers and farmers' cooperatives. The cooperatives have their business model configured around individual farmers and supplying a larger firm to access international markets. The individual farmers operations do not have all the components to shape a business model, because they have limited functions solely focused on operations and managing the relationship with the cooperative, the firm and external organisations. While they might not have marketing or logistics planning in the same scale, the operations mirror the larger firm's operations. These are often performed by the individual farmer and family members. In the following sections, several examples of often overlapping business models are used to illustrate the assemblage and linkages to changes in the business model in response to climate stimuli, which can influence changes in other behaviours or actions.

The first section establishes what constitutes the preliminary assembly in each case study, including the actors, practices and resources. In the second section, the types of climate risks and impacts are presented to establish the link to the business components of the different actors in the assemblage. These sections report on the different interviews and observations in each case study, to develop a simple model of linking climate impacts to business model components.

5.1 Assemblages under climate stress

The analysis of the UNFCCC database presented various elements of economic assemblages in different sectors undergoing climate stress. The reports of individual business cases indicated how some firms have begun understanding climate impacts and risk and deploying adaptation actions. The responses if individual firms are technical solutions addressing climate related stressors by seeking economic stability and advancing the firms preferred adaptation options, however the data raised questions about the tensions, trade-offs and the decision-making process between the firms, their associates and host communities to adapt to perceived and future climate impacts.

The analysis suggested that firms in the agriculture, and food and beverage sectors deployed a broad combination of resources to enhance adaptation capacities of a variety of associates and stakeholders. This indicated firms had undertaken adaptation to manage direct climate risks and begun to recognise adaptation needs of their associates as imperative for longer-term adaptation. The reports failed to explain the types of adaptation options available, the distribution of risks and benefits of climate change, or the link between the firm's business model and local dimensions of adaptive capacity.

The obligations and responsibilities of the members of the cooperatives were structured differently in the two cases with important consequences for local capacities: in the case of Scotland, the firm created a membership system that provided an open agreement for farmers to sell surplus crop production, while the case of Baja California the firm relied on contract exclusivity between the farmers, the cooperative and the firm. This business configuration had important consequences influencing farmers ability to accumulate new assets, diversify their sources of income or integrate innovations necessary to strengthen adaptation capacities. The next sections will explain these differences in further detail.

A connection between biophysical impacts of climate change and business model routines was established by a cumulative series of decisions to manage variable climate conditions impacting crops. Different types of climate stimuli influenced and shifted the focal firms' business model components by requiring readjustments through a series of adaptive actions that corrected routine disruptions in order to maintain economic functions. In mapping these adaptive actions, the spatial and temporal dimensions of business models emerged in the form of configuration of supply in geographic locations and business cycles.

The early work of economic geographers in the 'geography of enterprise' highlighted that spatial factors shape production decisions, such as firm location, labour and logistics (Walker 1989). In the context of climate change adaptation, to create value firms dependent on natural resources or climate cycles are particularly vulnerable to the impacts of unpredictable climate patterns, as different biophysical variables are linked to the economic calculations of the firm's profit seeking model.

The following sections build on this notion of spatial factors and revisits this concept to examine the different elements in each location that explain the linkages of physical impacts of climate change on business models in the two assemblages, highlighting the similarities and differences between the structure of the assemblages and the consequences for adaptation. This contrast explains the importance of business model configurations for building or protecting the factors that determine adaptive capacities, and the importance to integrate adaptation planning to steer the responses in the private sector to climate impacts towards relational views of adaptation.

The climate patterns in the different research locations have begun to experience changes associated with climate change. These type of changes and impacts are summarised below from scientific assessments and policy reports, and the perceived changes to climate patterns by local farmers. These sources provided evidence to establish the types of climate related impacts on the assemblages and research locations and link the diverse actions to adaptation. Assemblages might not have a boundary, which means individuals, materials and information can flow in a preliminary cluster of actors. An assemblage can expand when individuals have membership in different groups or introduce new information from different sources beyond the preliminary set of identifiable relationships. During the field research it was necessary to establish a boundary and scope for the interviews and data collection process, including limiting the geographic scale of the research. Informed by the business model, diverse economies and the adaptation literature the boundary of the research was established by the focal firm themselves. During a first working meeting with the Director of each firm and cooperative, a template with a diagram on the structure of the firm was presented to the individual. At this time, they populated the map by identifying the names, locations and linkages between the end point of the supply chain and the origin points of all the sources of grains, at farm level. This provided a set of relationships and processes, where the firm invests and extracts value, in the case of California for example, this included a map of hundreds of suppliers across two countries. The last supplier, both geographically and level of performance, was the limit of the business model, and within this boundary a selection of interview participants was selected based on diverse criteria, such as volume of production, location of exposure, historical performance and opportunity. The following sections provide the results of said interviews and observations during field work research.

5.2 Assemblage 1: The desert and the coast– upper and lower California

A focal firm in the California case study is the starting point of the analysis. This is an organic agriculture service company with operations in the U.S. and Mexico (the two supply chain components under analysis). The focal firm is headquartered in Santa Cruz, California, USA. It is the sole client of the associate cooperative and individual farmers located along the Lower California peninsula. The firm is established as a private business with shareholders. The corporate structure is headed by a Chief Executive Officer, Regional Directors and Senior Executives for specific operational units or departments, like sales, logistics and international production.

The focal firm owns and directly operates 7 open-field farms and 3 greenhouses in the US near their corporate offices. On the Baja California peninsula, the cooperative and affiliate firms have offices in San Jose del Cabo, Baja California Sur, Mexico, and Ensenada, Baja California, Mexico, respectively. These organisations mediate the relationship between the firm and individual farmers across the peninsula by allocating crops among the farmers according to the focal firm's sales projection, deploying resources and buying the farmers' harvest. Figure 11 illustrates the supply chain across the California and the Baja peninsula.

Figure 14 Organic Cherry Tomato Field. Photo by Author

The supply chain is supported by small- and medium-sized family farms across the US and Mexico. These individual farmers are connected to the international market through the firm. The cooperative was originally organised by the firm to configure its supply chain and promote local development in the region. This structure has functioned for over 30 years. The supply system is comprised of approximately 170 farmers across the Baja California peninsula and senior officers estimated that approximately 3,500 people, including employees, fieldworkers, farmers and their families, are directly linked to this organic production assemblage. The firm reported yearly sales of USD $ 100 million.

This agricultural production system was identified and selected as appropriate for mapping adaptive actions and understanding its different deployments of resources and business model configurations. Its geographic conditions and production structure allowed an exploration of the focal firm's ability to shape, create or block adaptation pathways in the sites of operations along the assemblage. The map in Figure 16 below indicates the locations and geographic scope of the firm's operations along the California regions.

Figure 15 Supply Chain of Organic Farmers.

The farming cooperative alone out of 170 registered members had 129 active farmers across the southern region of the Baja California peninsula. The cooperatives oversaw the farming operations, transferred financial and material resources to the local farms and provided technical support during the different stages of the growing cycles. The focal firm channelled these resources to the farmers through formal contracts established between individual farmers and the firm mediated by the cooperative.

In this model the firm guaranteed minimum income to the local farmers and established a set price, paying farmers upon receiving the produce in their facility. This mechanism formalized a closed relationship of exclusivity, where the members at the start of each growing season are allocated particular crops and production volumes dependent on their historical production capacity. This is a decision made by the directors and senior officers of the cooperative.

The focal firm based in California, U.S. invested in the farms through the cooperative to sow, grow and harvest a variety of organic crops, such as courgette, basil, rosemary, cherry tomatoes, eggplants, cantaloupes and watermelon, among many other varieties of produce. The amount of the investments at the start of each year's agricultural cycle are gradually repaid by each individual farmer over subsequent weekly or monthly harvests.

The resources included capital investments for green compost, diesel for combines, seedlings to plant in the field, wages to pay labour before the first harvest and other needed material resources, such as irrigation materials and infrastructure. During the harvest seasons, the cooperative collects and packages the different crops at sorting facilities near the farms. These sites monitor quality and ship the vegetables, fruits and aromatic herbs to the distribution warehouse in Los Angeles, California, for final wholesale to supermarket chains across the US.

There are other types of farmers in the supply system in the northern locations of Baja California, Mexico. These are independent farmers with a different pricing model, where they invest their own resources at the start of the growing season and obtain payment for their crops based on the market prices and once the produce has been paid to the focal firm. These farmers, have an open supply arrangement with the firm, which will have important consequences for the adoption and diffusion of innovations as it will be explained in the following chapter.

5.2.1 Changing climate patterns and extreme weather events

According to the U.S National Science Assessment (2014), State of California is likely to experience increased heat waves and high temperatures during the year, reduced ice pack in the winters, recurring droughts, wildfires and insect outbreaks, all associated to climate change. This presents the risk of declining water supplies, reduced agricultural yields, additional health impacts in cities due to heat stress, flooding and erosion in coastal areas from the changing climate patterns.

For example, in 2015, California experienced an intense drought that impacted agricultural production. A recent study by the University of California, Davis calculated economic losses by the losses in crop production, lost revenue by firms and the government and finally employment in the agricultural sector, which is seasonal during harvest months. These economic losses combined were calculated at 2.7 billion US dollars, and 21,000 jobs lost (Howitt et al, 2015).

In the Baja California, Mexico recurring hurricanes and flash floods during rainy season in the peninsula, as well as extreme temperature variations, such as sudden frosts in the winter and heat waves in the summer. These recurring hydro-meteorological are impacts associated with climate change, impacting agricultural productivity in the region. Also, water related problems, such as salt-water intrusion into local aquifers critical for agriculture (Lujan and Romo 2010) in the northwest areas, and declining fresh water reserves are adding pressure on water resources, with a projected shift from "very high pressure" to "critical situation" by the year 2030 (NCC, 2015), as the following figure 12 shows.

In the southern part of the Baja California peninsula, extreme semi-arid weather conditions average temperatures averaging 50 degrees Celsius in the summer, and experiences recurring hurricanes and tropical cyclones with increasing intensity. The strongest, Hurricane Odile, a once every twenty-five-year magnitude event, occurred in 2013, resulting in 11 deaths and an estimated US $1 billion in insured losses according to the National Hurricane Centre Tropical Cyclone report (2014).

Figure 16 Projections of water availability under climate change. Source: National Climate Centre, Climate change adaptation plan (2015).

The highest level of climate and disaster risk was identified in the southernmost part of the peninsula where most of the organic farmers in the assemblage are located, where the impacts included floods, land erosion, high levels of humidity and moisture, and salt water intrusion and saltation over agricultural land. This last impact refers to the movement of hard particles such as sand over uneven surfaces from the flow of water rendering productive agricultural land covered with sea side sand.

In previous years, the occasional hurricane or tropical storm would affect the region during the sowing or transplanting of seedlings cycles, but the frequency of hurricanes presented added severe risks for local crops. The farmers part of the firms supply chain are growing crops under complex operational scenarios, also inserting considerable challenges for the focal firm. The organic farming operations are highly sensitive to weather variations and required rapid combination of measures to adapt local farming systems to changing climate conditions.

The different responses over the past years to different measures to address climate related impacts, have focused on emergency relief, where the efforts of the firm and farmers had focused on rapid recovery to prepare for new agricultural cycles and accessing government aid assistance to replace equipment and infrastructure. The farmers', cooperative management officers and the firm's employee's continuous observation of and interaction with the environment in their agricultural region allowed them to perceive the slightest deviations from normal weather patterns and climate conditions over long periods of time providing important information on the diverse types of current and perceived impacts of climate change.

The experiential element of their close interaction with the environment as a source of relevant information on climate (Gamble at al. 2012:168 citing Osunade, 1994; Ovuka and Lindqvist, 2000; Roncoli, et al, 2002; Luseno et al. 2003; Meze-Hausken 2004; Vedwan, 2006) is a legitimate source to document and establish climate impacts.

The regional and historical data indicated the climate variability and natural hazards at regional level, providing information on the local context and the expected impacts directly affecting the production and business operations of the assemblage. According to the State of Baja California climate change action plan, the data suggests that temperate value changes projected could rise by 2 degrees by 2099 (Ivanova et al. 2012) and indicated that over 11% of the territory is severely degraded with a high likelihood of rapid desertification.

The following table 9, is a summary of the information on climate associated impacts was collected through interviews with farmers and the cooperative officials, and the climate change assessment report.

Table 9 Climate and disaster risks in the three California's.

Climate and Disaster Risks and Impacts in the California's		
Baja California Sur, MX	Baja California Norte, MX	California, US
• Extreme weather conditions • Inland and riverine flooding • Fresh water aquifer depletion • Heat stress to people • Hurricanes and tropical storms • Increasing high temperatures • Land erosion • Pests arising due to increasing humidity levels • Plant disease, especially in basil (downy mildew) • Transmission vectors of plant disease from urban area • Saltation processes over fertile soils	• Drought • Pests • Plant disease • Quick frosts • Rising sea levels • Santa Anna dry winds • Wild fires	• Drought • Wild fires • High wind events (Santa Anna hot winds) • Earthquakes

5.2.2 Climate Impacts and Business Routine Disruptions

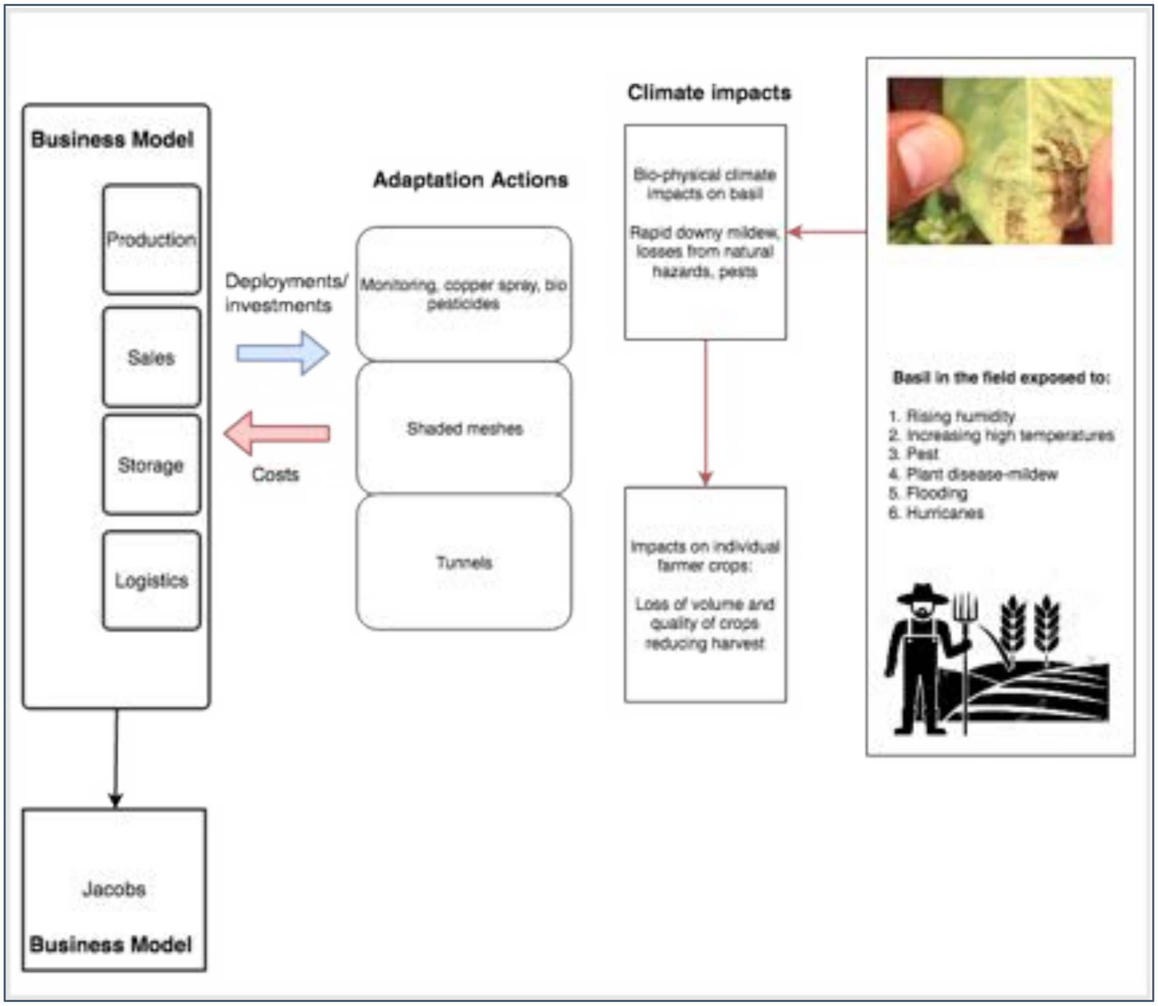
In Baja California, the observed adaptive actions aimed to manage a variety of climate-related impacts. Extreme weather events like flooding and hurricanes disrupt business routines and hinder the ability of farmers in the supply chain to maintain harvest yields in each agricultural cycle. These impacts result in crop losses and increasing costs and demand better monitoring to protect plants from pest and disease. The figure 18 below uses the example of organic basil to illustrate the observed connections between the biophysical impacts of a changing climate and business model components.

This crop was the predominant and preferred higher-value crop for the farmers in this region as the prices in the US market led to financial gains. In this location, organic basil was also the product to experience the most sudden decline in production volumes in the region as a result of changing climate patterns, such as increasingly extreme heat during the summer months, flash floods and, increased moisture and humidity that resulted in higher prevalence of plant disease and pests which decimated crops before the harvest. These impacts represented the highest financial losses and income-changing impacts experienced and reported by local farmers.

The figure 14 below illustrates the connections between fungus disease on the basil leaves and components of the firm's business that determine the configuration of the business model and external firm relationships. The reported types of actions that contribute to adaptation in the local farms included, for example, the use of copper compounds to inhibit the emergence of seed-borne fungus during periods of extreme variations of temperature and moisture, which combined lead to plant disease, and growing infrastructure to provide better control of external environmental conditions to prevent pests and disease.

The figure presents the combination of factors affecting one high-value crop. The example used was for organic basil, as this was the traditional crop grown in the region for the focal firm, but also the higher in market value. The combination of rising humidity levels and high temperatures, created the conditions for the emergence of a fungus in the plant, mildew. The same combination of climate conditions had given rise to a variety of new pests, such as a particular type of field flea and other small insects feeding on the crop. In addition, other climate related risks such as recurring floods before harvest or intense hurricanes had over the past years impacts basil production to the degree of having lost entire crops in the past years.

Figure 17 Climate Impacts and Business Model Organics.



The firm, cooperative and farmers had deployed a series of measures to combat recurring impacts and emergence of field problems associated with climate patterns, including organic and mineral pesticides to control plagues, using meshes to shade and protect the crops and micro-tunnels to protect seedlings before transplanting them to the open field for harvest. These measures included changes in the cost structure of the firm, requiring reallocating resources for investing in the infrastructure, assigning personnel to monitor plant growth or assist individual farmers in the deployment of new infrastructure. While the changes might directly involve different departments in the focal firm or cooperative, such as production and storage, the shifting resources and business routine adjustments will also impact sales, logistics and general management.

The crop-related losses affected the firm in different ways, first by demanding additional inputs and deployment of experts to monitor the fields, increasing production costs; secondly, sales team's projections, harvest planning and client relationships became uncertain limiting the firm's ability to ensure a steady supply of specific crops. Finally, the storage and packaging facilities required to develop processes to manage incoming crops and increase control to avoid damages to the produce, and the logistics costs increased due to imperative to increase transport schedules to move the products.

These disruptions of business routines are informing the configuration of the business model, in some ways, testing the efficiency and efficacy of the model. When these impacts continue in increments to represent losses or investments, solely to maintain the same level of productivity, a reconfiguration of the model becomes necessary, where shifts to supplier locations or relationships can be expected. The farmers in this location are distributed along the coastal areas, but also bordering in some locations with the urban environment. The figure 19 below shows the close proximity of organic farming operations with the city on one side, and a deserted river that becomes a flood risk during hurricanes and high levels of rain fall.

Figure 18 Locations of Farmers Zone 1, Baja California Sur. GIS Image. source: Jacobs del Cabo

The extreme weather conditions like recurring hurricanes and floods increased the levels of moisture and humidity on the fields, accelerating the conditions that resulted in increased pests and plant disease. The local farmers reported losing entire crops of basil, cherry tomatoes and aromatic herbs in the short period of 24 hours when weather conditions fluctuate rapidly; for example, if sudden onsets of rain cause flooding and then are followed by rapid increases in temperature in the region. The basil crops developed a fungus called downy mildew that decimated the plants and a type of local plant flea emerged under these extreme climate conditions, affecting cherry tomato crops at early growth stages.

The losses in crops resulted in low basil yields in months when market prices are high in California, U.S., which limited the farmers ability to benefit from these higher market prices. This entrainment gap or lack of synchronicity between planned production cycles and market demand cycles resulted in significant economic losses for the entire assemblage, the focal firm and the farmers. The farmers in the region of San Jose del Cabo explained that rapidly onset of high temperatures and flash floods led to rapid appearance of plant disease, and the types of crops are highly sensitive to weather variations. A farmer in the vicinity of the urban area reported that measures often are not timely, as the velocity of climate related impacts can decimate the crop in a few hours when the combination of heat and humidity reach their highest levels.

"We lose the crops in a day, even a few hours with these conditions" Farmer, Basil grower in the region of San Jose del Cabo

The shifts in the harvest windows along the supply chain in the southern locations, then impacted the business model of the focal firm. The losses destabilised the supply and prompted the focal firm's officers to assess different options to maintain the financial viability of the firm. These calculations presented important trade-offs for the firm, which under normal climate patterns could be considered as normal risk parameters, however recurring intensity and frequency over the past years, have led to some officers to consider the alternatives, including moving the supply chain.

" When the production window moves because of flooding or humidity, they [South BC Cooperative] don't have harvest in the time they are supposed to in December and we need to find supply from elsewhere… but it's not easy, nobody wants to contract for just some months of produce, supply agreements require longer commitments. If we buy from somewhere else, that takes from what we buy from Baja" – Firm Operations Manager in Charge of the Supply Chain for the Peninsula of Baja California

These trade-offs resulted from climate related stress on normal business routines. While agricultural production has always been subject to weather changes and varying harvest yield each year, more frequent extreme weather events and continuous increments in temperature, are leading to more stark choices for the firm and the local farmers. These types of climate-related impacts were reported at different points in the production system, and in response, the firm had made incremental adjustments to the field monitoring activities by increasing expert visits and investing in infrastructure to control plan growth and temperature and begun a cross-breeding program to develop basil variety resistant to the local changing climate conditions. These responses were deployed in response to the emerging problems derived from perceived climate impacts, both by the farmers and the firm coordinators.

The spatial factors are critical to the configuration of the firm's relationships. In these locations, financial value was shaped by the supply chain's business model configuration, which was established according to the firm's desired production levels and varieties and considered the climate patterns in different areas to maintain stable production of specific crops throughout the year. Allocating resources and information across several locations with different climate patterns can help compensate for losses in another location. In this case, the spatial factor is a dynamic element of the business model.

The temporal dimension represented by the cycles or routines of agricultural production, are tightly connected to the spatial components of the business model. These elements informed the business strategy and planning activities to seek profits, lower costs and create value. However, increasing failures and interruptions in the supply chain resulting from direct climate stimuli prompted longer-term reconfigurations to maintain the adaptation space of the firm within the assemblage. For example, reducing sourcing volumes from certain locations and seeking new sourcing locations, or permanently eliminating certain crops from the growing rotation.in the case of Baja, agricultural land had been repurposed from the capital reserves to productive agricultural land, shifting the value of the firm and reconfiguring risk. In agricultural production, the produce trading firms and the farmers operate within narrow windows of time to perform specific routines such as seeding and harvesting dependent on climate patterns. The shifts in harvest windows or increased impacts of extreme weather have created uncertainty around crop volumes, projected revenue and harvests. The types of incremental responses to manage these climate impacts, included changing the allocation percentages of planned crops volumes to certain farmers to concentrate production solely with high-performing farmers, seeking to maintain revenues for the cooperative.

Figure 19 Basil harvesting in Baja California

The recurring extreme climate events and nearby urban centre compounded risks for farmers. It was reported that hurricanes had increased the types of plant diseases observed in the crops by farmers. While most farms are located a few kilometres from urban areas, several high-performing farmers are located within the urban periphery, and the firm's agronomists had identified that debris from the destroyed buildings and wooden structures in the city acted as transmission vectors for a fungus that originally only affected trees in the urban area. The vectors transported pests with the high winds created by hurricanes impacting farming areas, which created new risks for farmers. A farmer in the region close to the firm's headquarters in the urban centre explained:

"We found wood and pieces of palm trees from the town that were infected in the field, this brings disease specific to those plants that was not here before" Local Farmer Member of the Cooperative

Figure 20 Downey Mildew on Basil Leaf. Photo by Author.

These new types of diseases from urban areas are specific issues affecting peri-urban farming operations and highlighted the relationship of different sources of rural and urban climate impacts affecting the agricultural activities of the community. The more frequent and severe natural hazards, particularly those occurring during advanced growth cycles of crops, increased the losses from climate-related impacts.

The past sections served to demonstrate the relationship between biophysical changes emerging from climate, and the components of the business model. This first section solely focused on the firm-cooperative and farmer relationships undergoing climate stress. In the following section, the similar assemblage will be presented to illustrate a different configuration undergoing climate stress.

5.3. Assemblage 2: The Black Isle, Highlands, Scotland

The second location for field research was the Black Isle in the Highlands of Scotland, where Highland Grain Farmers Cooperative was set up by 12 farmers in 1977, and today it has 85 active members. The farmers and cooperative collectively produce 42,000 tons of barley each year and focus their supply to the distilling market in the Highlands of Scotland. The cooperative reports indicated that cropping is mainly focused on spring barley, and some oilseed and oats. The following figures X and Y show the area where all the 85 farmers members of the cooperative are located.

Figure 22 Black Isle, Scotland

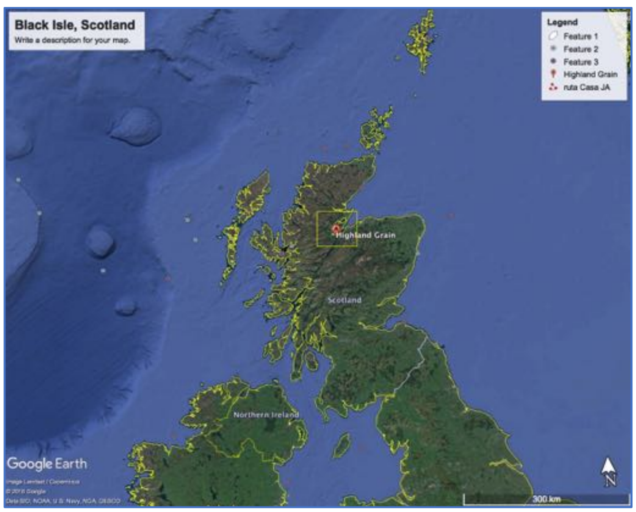


Figure 21 Highland Grain Cooperative

In this assemblage, the individual farmers, the cooperative and the distillery, are linked with an additional actor, the maltster. There are four main scales in the supply chain, and more external pressures on production as distilleries buy directly from maltster, not from the barley growers or the cooperative directly. The role of the cooperative in the supply chain has been to establish long term supply arrangements with the distillery and malting company to create stability and manage pricing risks for the growers.

The cooperative according to their operations report acts as "a conduit between distillers and growers to assist famers in meeting the demand and the specifications of the distillery each year". Their focus is on energy efficiency, drying and storage capacities to alleviate the pressures on production and protect yields. These are the basis of the Black Isle barley-whisky assemblage.

5.3.1 Changing climate patterns and extreme weather events

Recent studies (SCRI, 2007, ACCSG, 2009, SCCIP, 2011, CCRA, 2012) have predicted climate and extreme weather risks for Scotland in the next century. There is a reported high likelihood of average temperature in the region rising by 3.5 degrees, summers becoming 50% drier with average increases of 40% humidity, and rainfall increasing in the winter with 90% less snow. This may result in more extreme weather temperatures and rainfall events These changing climate patterns will lead to the spring starting almost a month before the typical dates for areas north of Britain, creating conditions unlike anything in Scotland today.

These changing conditions will make it very likely that extreme events, such as floods, heat waves and heavy rainfall, will become more common and recurrent in unexpected times of the year. The climate change reports also highlight consequences and impacts for agriculture from changes in biotic and abiotic stress factors, energy and transport, human health, food supply, business resilience and even the cultural heritage and identity of the region. The conditions under which communities and businesses in a traditionally agricultural region adapt is a central concern outlined in policy reports and adaptation strategies proposed by the regional and local governments (SCRI, 2007, ACCSG, 2009, SCCIP, 2011, CCRA, 2012). Climate change impacts are likely to have important consequences across diverse social and economic dimensions at the individual, household, community and regional scales.

In this context, climate change stress will augment pressures on local systems in the Whisky industry supply chain, where farmers, cooperatives and distilleries are coupled in tight production clusters. These actors are interdependent parts of a regional supply system that transforms local raw materials and agricultural output into high-value products for the international market.

The Scotch Whisky's entire production chain must be studied, from primary production to storage, distribution and utilisation of local products, for adequate adaptation strategies to be devised (SCRI, 2007). The value and opportunities deriving from climate change will occupy different the various stakeholders along this system, with potential trade-offs that could result in either zero-sum situations or coordinated engagements that culminate in higher degrees of local resilience.

Figure 23 Barley Farmer, Scotland. Photo by Author.

The warmer weather suggests that prolonged springs and summers are likely to feature more intense periods of rains and floods. The potential to manage the wetter winter season will need to be developed, as this is expected to impact storage and crop management. Climate impacts on harvests will result in increasingly difficult transportation logistics due to high demand in shortened harvest windows and in higher costs, including those related to the investments needed to curb the impacts of seasonal droughts that interrupt agriculture.

The different climate and disaster risks in Scotland are summarised in Table 10. The data was derived from different reports, assessments and direct observations from farmers. These climate risks will have consequences for current business models and the configuration of business processes along the production chain. These are already being experienced in the small agricultural areas on the eastern coast of Scotland, which is a small cluster of agricultural and industrial production of Scotch Whisky.

The region of the Black Isle where 80% of barley for distilling is grown in Scotland is already experiencing extreme temperature changes during the growing season in the range of 7 to 12 degrees annually (Report 2012). The region where most barley crops are grown in East Scotland will experience even greater changes as the number of days where there are heatwaves will increase to 12 to 15 days on average. These climate risks have begun to affect longer-term infrastructure investments, as well as short-term agronomy decisions on the farms and fields.

Table 10 Climate and Disaster Risk Scotland

Climate and Disaster Risks in Scotland
Scottish Highlands
• Floods
• Drought
• Plant disease
• Heavy rainfall
• Temperature variations
• Increasing field moisture
• Warmer summers

• Heat waves
• Decreased snowfall

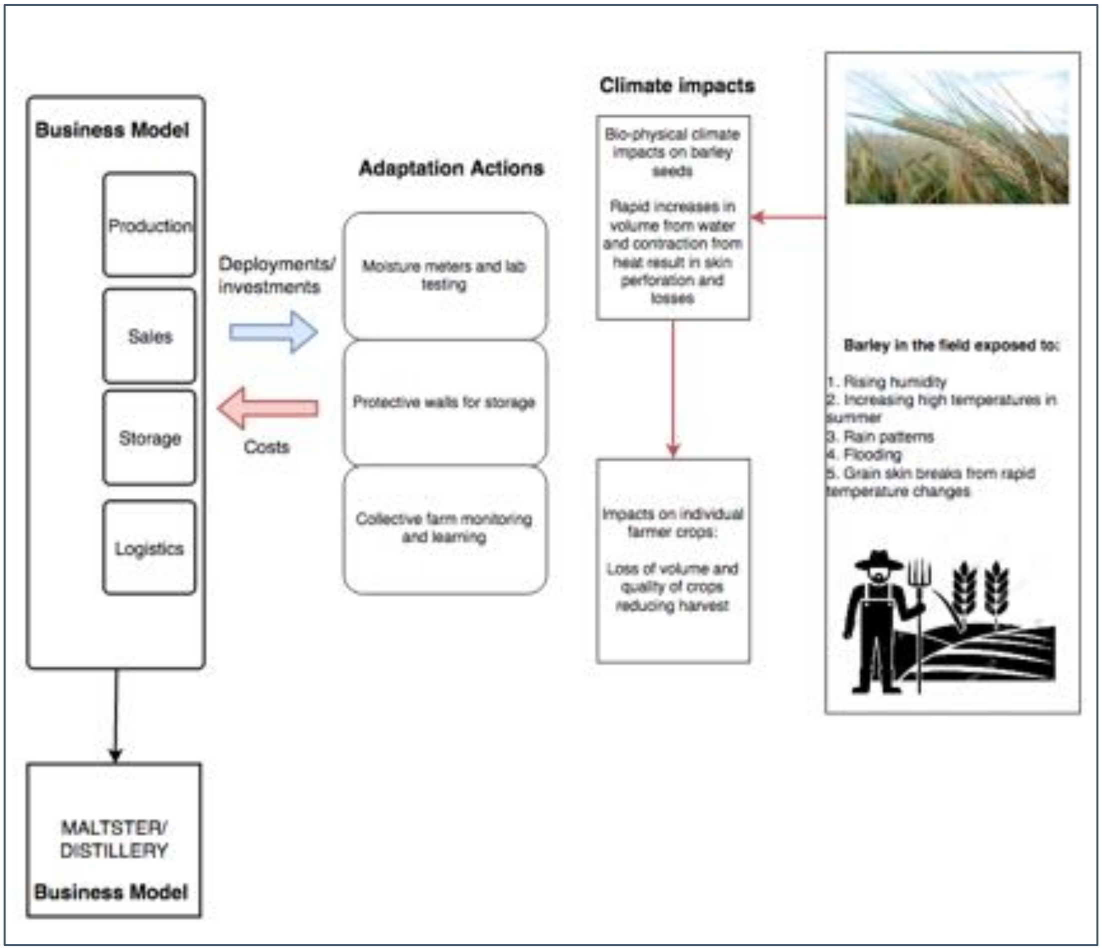
The selected field site is the Black Isle peninsula. This region is home to a wide variety of stakeholders with historical ties in the production of barley and spirits in the region. About 70 percent of barley production in Scotland is concentrated in this region. The Scotch Whisky association has recognised the potential climate and disaster risks the industry faces. Production is closely linked to Scotland's environment, culture and geography. The agricultural activities in the Highlands mainly include growing spring barley and wheat, and the distillery process considers the use of local water resources as a main contributor to the quality of the products.

The firm Highland grain is one of the two major cooperatives organising the farmers who produce much of the grain needed for malting and distilling in Scotland. The cooperative was started in 1977 and currently has 89 active members. These farmers produce 42,000 tons of malting barley year, representing over 70 percent of the entire barley production for use in the Scotch Whisky industry in Scotland. The study sites were in the coastal area of the Black Isle and sections of the eastern coast of Scotland.

5.3.2 Climate Impacts and Business Routine Disruptions

In the case of Scotland, the connection between business routines and climate-related disruptions was established by mapping the logistics and harvest routines in areas where the firm, cooperative and farmers had been impacted by changing climate patterns and extreme climate events. A variety of spatial and temporal elements embedded in the model shaped adaptive actions. The figure 21 below illustrates the connections between these elements, were aggregated impacts on individual farms will add pressure on the various components of the model.

Figure 24 Climate Impacts and Business Model Scotch Whisky



The business models in the distilling industry are connected to this specific geographic location to draw financial value. The characteristic spatial fixity is based on the quality of water and denomination of origin for Scotch Whisky products from the Highlands. The sourcing of barley grains, however, is not restricted to this geographic location. The current denomination of origin policy (see Scotch Whisky Regulations, 2009) extends a protection to distilleries by allowing them to source grains from any location, but they must distil the spirit in the region with Scottish water in the region to receive the denomination of origin certification.

The policy excludes from any protection the cooperative and local barley farmers, and these differences in spatial fixity for the farmers and the distilleries highlighted their differential ability to generate income by seeking to produce in alternative locations with lower levels of climate risks. This flexibility can translate into adaptive capacity.

Figure 25 Monitoring Farm Meeting, Scotland.

The business model configuration creates an additional challenge for the sustainability of farmers in the biological assemblage undergoing increasing levels of climate stress. The predicted warmer weather will impact the storage of finished spirits as accelerated evaporation levels will affect spirit volumes and reduce profits from the most valuable older whisky products. According to reports of local farmers, shifts in weather or climate patterns have delayed the harvest by two or three weeks in the past years, causing competition among farmers to harvest the barley as quickly as possible in the small windows between rains. The longer barley stays in the fields, the higher the risk of climate-related impacts on the crops. Very tight schedules also guide the drying of the grain, leading to higher costs and risk for everyone.

"We [distillery] lose about 10% of spirit to evaporation each year, normally, so if weather increases evaporation reduce the volume in barrels of higher value, aged over 20 years" Distillery Manager

This type of configuration of business routines will need to be adjusted to reflect the competition that occurs due to tighter harvesting windows. Accounting for the risks derived from delays will prompt the firm and cooperative to seek secure production alternatives. This would extend the adaptation space beyond the firm to include the associates and suppliers. In business model configurations with specific attachment to unique geographic locations, the central feature of the spatial element of the business model is location. The location of the firm's assets and infrastructure is determined by geographic requirements to produce Scotch Whisky. This is unique to these firms, which cannot move or relocate as an adaptation measure. Challenges posed by changing weather and climate patterns must be addressed through technological or operational adjustments.

The location imperative is a core condition for the stability of the distillery's operations, as both, the reputational and financial value of their product derives from the location of production. This is inverse of other firms' situations, where value can be drawn by shifting their supply chain to areas of lower climate risk, sourcing the raw materials from alternative regions or supporting relocation efforts to raise efficiency. For distilleries, however, managing climate and disaster risk becomes a core operational demand.

While independent adaptation is already occurring at farm level, the role that a firm's business model can exert influence and arrest adaptation processes to force specific options that accommodate their preferences, such as the type of barley grain grown for distilling, have begun to shape the adaptation capacities of the individual farmers. The establishment of private sector driven adaptation regimes for the communities in the region is a highly likely scenario, one which, requires making explicit the underlying drivers of firm's adaptive behaviour and their relationship to the ability of individuals and groups in the community to accrue new assets, reinforce infrastructure, integrate technology or develop the ability to foresight necessary for choosing the most desirable adaptation options.

5.5 Assemblages, Adaptation Actions and Adaptive Capacity

The past sections presented empirical evidence from the primary assemblages, which included diverse adaptation actions of a focal firm, farmers' cooperative and individual farmers. In this section, the common and contrasting uses of technology, business arrangements and the different organisations introducing new information and resources into the assemblages, are identified as to understand how individual firms place barriers or enable adaptive capacities.

The actions that contributed to adaptation observed during fieldwork or reported by interviewees triggered routines changes or reconfiguration of the firms' business models that shifted resources and information flows between the firm to the farmers or the cooperative. These actions contributed to adaptation capacity but have not been documented or understood in the context of adaptation. This prevented more strategic transition from independent adaptation towards deliberate adaptation processes across the assemblage, and in some cases highlighted the potential for forced transformational changes arising of actions intended to cope with climate impacts.

The following sections will explain the different types and combinations of actions to expand the taxonomy proposed in Chapter IV, with several new types of adaptation actions not previously identified, and explains the trade-offs and opportunities arising out different collaboration activities among assemblage members. This new information allows to argue how business models in the private sector, can both enable and limit the ability of a community to transition into socially just adaptation regimes.

5.4.1 Financial Resources

The table 11 below shows observed and reported financial adaptive actions of the firms in both locations, these illustrate the connections between the firm business model and the different actors in the external assemblage.

Table 11 Financial Resources as Adaptive Actions

Category	Actions deployed	Contribution	Case
	Action	**Contribution**	**Location**
Financial resources and in- kind donations	Seedlings of alternate crops during summer months: corn and beans	These provide alternative sources for food security during high temperature months of non-crop production	Baja California, Mexico
	Food and income relief (3 months)	Disaster recovery relief and addressing vulnerabilities from food security and loss of income	Baja California, Mexico
	Financial investments that allow farmers to kick-start the season; buying inputs such as seeds, fertilised	Increased flexibility and security on production inputs	Baja California, Mexico
	Tying price to futures market	Provided a stable price for the farmers in years of crop losses	Black Isle, Scotland

After Hurricane Odile, the firm channelled financial resources through the cooperative to farmers in the form of direct cash transfers to alleviate the impacts of the most intense tropical hurricane to hit the peninsula with recorded wind velocities up to 200 km/hr. This natural hazard became a disaster for farmers when it impacted the growing regions in peak harvest season, devastating the farms' crops and infrastructure. The financial resources provided relief to all the farmers members of the cooperative for 3 consecutive months which were affected by the hurricane. This financial support helped supplement family income after the disaster-related losses.

The cash crops, such as corn and lentils, combined with financial resources provided critical resources that supported household food security and local livelihoods, as they benefited not only individual farmers, but their immediate families part of the farming activities. The emergency relief food baskets and cash transfers were considered routine and necessary practices to preserve the farmers' ability to plant crops in the following growing cycle and prevent productive decline. This 3-month relief program was motivated by economic calculations and illustrates a type of short-term measure to manage extreme climate events, suggesting that deployment of these resources reaffirmed the firms social licence among the community, but also ensured the recovery of farmland and continuity of local operations.

The actions sent a strong signal of support to the community reinforcing trust in the relationship with the firm and enhanced momentarily the farmers' ability to cope with immediate losses. This short-term disaster risk management measure, could become an entry point to integrate practices into their operations that would allow adaptation planning as routines in the business cycles. These examples of economically efficient practices were not documented by the firm to understand their relevance for local families, but they point to the importance of linking economic and social calculations when mitigating against continuous extreme events and developing resilience to disasters.

The firm's officers can learn from these measures and understand how to project investments for future adaptation measures, a preliminary step would be for the firm to document the activities and include the input from the farmers involved in the program. The studies on adaptation in the private sector indicated investing time and resources into documenting these activities was not a priority, but this suggests it also becomes a barrier for adaptation. Without the possibility to document and establish a common technical language and understanding of the outcomes of any investment to build adaptation capability, the learning loop is arrested at the first stage, leading to repeating actions to respond to climate impacts.

Different adaptive actions could extend beyond the short term by establishing formal mechanisms to protect suppliers from going under a certain income threshold, particularly in the case of low performers. The insertion of additional resources to the assemblage in the form of emergency resources allowed the system to maintain production and cope with external shocks, sustaining economic functions in these production zones.

The crop losses were absorbed by the focal firm in addition to the financial support and food supplies provided to the farmers. This strategy could have provided longer-term benefits if there would have been an effort to document the program and understand the benefits or detriments of maintaining marginal production, instead of seeking to empower individual farmers by creating a practice that solely focused on the short-term relief.

The previous example described a direct financial transfer mechanism to cope with external impacts associated to climate change, but other financial mechanisms can be used to deploy resources that mimic adaptive behaviours. these might not be recognised as adaptation by the firm, as they can be considered as business practices to increase revenue flows for the cooperative and the farmers, however the characteristics of developing foresight, flexible institutional approaches to maintain system functions and innovation contribute to building adaptive capacity.

This is the case of the cooperative in Scotland, were the cooperative director secured additional financial resources by linking their pricing strategy to the futures market. This allowed the cooperative to maintain a secure range of resources for the crops, which, in some years, could become additional financial flows. The cooperative acted as an intermediary that enhanced their members' ability to accumulate resources by exploring alternative pricing mechanisms to leverage in their relationship with the firm, which created a small pool of investment capital for assemblage members.

This alternative mechanism to gain additional financial resources opened an adaptation space and incrementally is shaping farmers' capacity to cope with climate-related losses, by allowing them to overcome a year of low yield harvest The, futures markets compensated, maintained or increased the farmers' economic gains. This strategy was reported by the CEO of the Cooperative and confirmed by a member of the board of directors, acknowledging the benefit of working with a pricing mechanism that circumvented having to renegotiate with the distillery every year, as expressed by the member of the Board of Highland Grain Cooperative:

"Of all the things we have done, Simon understanding the futures have given us a competitive edge. We don't speculate, we do it with what we already have in storage. We grow and that is all we put in black and red. We don't put things that wouldn't be good for the cooperative if it went the wrong way." Board Member of the Farmers' Cooperative

This mechanism was considered an important factor that provided certainty and security for the members of the cooperative allowing them to have a degree of control to independent of the influence and preferences of the distillery. This practice created a space for farmers to focus on efficiency and production, which suggests the ability of the cooperative to establish a mechanism with a degree of independence contributed to a potentially positive and sustained adaptive process in the community. The CEO of the cooperative in the Highlands, explained:

"Our price and contracts are based around futures markets. We don't try to negotiate on price and we can concentrate more on quality, then we can improve our reputation as performance supplier."

- *Highland Grain Cooperative CEO*

This mechanism provided the cooperative members some control over the decision on pricing and quality, which otherwise would have been determined by the distilleries' business model driven economic calculations. The futures market helped the cooperative develop the pricing mechanism as a strategy to increase the gains from their crops, leverage price and increase profits by gradually selling the harvest throughout the year, depending on the market prices. This is a form of entrainment, or a failure to synchronise different cycles, which resulted in the higher economic benefits, enhancing the capacity of the assemblage to manage climate variations.

5.4.2 Infrastructure

Infrastructure is a critical asset for developing adaptive capacities. Different types of infrastructure were observed as contributing to adaptation in the local assemblages, such as reinforced warehouses to safely store product during floods, retrofitted industrial dryers, small on-site farm drying containers to control moisture of barley seeds and micro-tunnels and meshes to protect crops from climate extremes, pests and the emergence of plant disease.

The deployment and use of these assets illustrates the changes to firms' business models linked to changing climate patterns, and the connections between the type of infrastructure, the manner and sequence of deployment and the enhancement or erosion of adaptive capacities of the firm and other members of the assemblage.

An examination of different adaptive outcomes suggested that origin of deployment, co-production of local innovations and pre-existing capacity were all central to the successful integration of infrastructure as a resource for adaptation in economic assemblages. The following table 12, presents the different actions related to infrastructure in both case studies.

Table 12 Infrastructure as Adaptive Actions

Category	Actions	Contribution	Case
Infrastructure	On farm storage facility	Provided the farmer the ability to cut barley and dry on site to reduce risks to barley seeds from changes in rain patterns, moisture and heat in the field.	Black Isle, Scotland
	Flood protections	Disaster risk reduction measure protected barley fields and on-farm storage facility	Black Isle, Scotland

	Pilot Macro and Micro tunnels projects	Extended the production of crops, control of humidity and pests for higher yields of organic crops. Sustains income.	Baja California, Mexico
	Meshes (37 installed)	Extended production of crops, control of humidity and pests for higher yields of organic crops. Sustains income.	Baja California, Mexico

In the case of the Scotch Whisky distillery in Scotland, infrastructure was a form of adaptive action that contributed to climate change mitigation and adaptation. This type of adaptive action was described in the taxonomy as a financial mechanism of mixed adaptation and mitigation actions, which transfers the savings and financial value generated by mitigation to finance adaptation. In this case, however, the financial value and contributions to adaptive capacity resulted from the ability to store more grains by rapidly drying incoming shipments from the individual farms, which was primarily due to the retrofitting of the cooperative's grain dryer. This raised its efficiency and reduced the costs associated with its operation.

The farmers' cooperative improved the drying process by recirculating the vents of the industrial drier used to provide services to all members. Five vents were used for drying, but fuel was only used to power two. The hot air from those two vents was then recirculated to the remaining three. This innovation resulted in the same level of efficiency, but with drastic decreases in diesel consumption and lower operational costs across the assemblage. The cooperative's increased capacity to dry grain reduced the risk of grains being kept in the field under unpredictable conditions after the optimal harvest window had passed.

The cooperative's efforts to retrofit pre-existing infrastructure to dry grains (see figure 13 below) stemmed from a combination of new knowledge introduced into the cooperative's routines by a graduate student analysing agricultural drying equipment and the warehouse operator's experience with the equipment. The collaboration resulted in the co-production of a high efficiency dryer that allowed the logistics department to accelerate grain collection from farmers, minimising their wait at critical harvest times and reducing climate risks.

The economic calculations of Senior Directors allowed the cooperative to improve efficiency and logistics, transferring the savings from lower operational costs to the farmers and reducing CO_2 emissions. The assemblage members enhanced their adaptive capacity by minimising the time needed to move greater volumes of grain at critical times and greatly enhancing the storage capabilities of the cooperative. This strengthened their ability to make more deliberate choices on crop management, transportation and storage. The example illustrates how the cooperative leveraged complementary technical skills to introduce changes in the business model that led to recalibrated economic calculations, which meant lowering costs of operations and transferring the savings to the members of the cooperative.

Figure 26 Retrofitted Industrial Grain Dryer, Scotland. Photo by Author.

The connection of this innovation to components of the business model provided the assemblage with the ability to better manage operations under increasing climate risks that demanded faster response times for harvest collection and drying the grain and rapid storage for transfer to the distillery. Climate-derived risks require farmers to monitor the grain's moisture levels while in the field. In recent years, temperatures and climate conditions have shifted harvest times by an average of 2 weeks, giving the cooperative and farmers more narrow windows for collecting the grain once it has been ploughed and increasing logistical demands on the cooperative to transport seeds to the drying facility. This was confirmed by a farmer's log dating back to 20 years of harvest dates, during the interview respondent X explained.

The economic incentive ensured the integration of the innovation into the model, while simultaneously protecting core income-generating crops of individual farmers. The use of pre-existing resources combined with new knowledge and onsite local skills resulted in contributions to adaptation and mitigation outcomes. The change in the cooperative's strategic operations had important consequence for local adaptive capabilities. The actions were clearly identified, documented and integrated into financial and operational components of the business model, normalising adaptive actions in long-range planning. This demonstrates that including such innovative actions in business models can enhance adaptive capacities.

In another example, in this same assemblage, the Scotch Whisky distillery firm strategically planned new investments in infrastructure to protect critical assets. These investments were normalised calculations part of the business model, which relies on extended periods of storage and maturation as the main source of the product's value. The firm recognised that extreme climate events required a longer-term planning horizon and took expected temperature changes and flooding into consideration when determining the optimal type of infrastructure for the maturation warehouses.

Within their natural business cycle, maturation takes a minimum of 3 years and can take up to 20 years. The firm's extended planning horizons facilitated the long-range planning and foresight needed for adaptation investments, as demonstrated with the adaptation assessments informing the design of reinforced warehouses. The firm kept these actions that contribute to adaptation confidential to protect investor confidence but continues to recognise local climate risks and advance adaptive actions by establishing priorities and setting minimum requirements for infrastructure that must be met in all future investments.

> *"There are physical risks of maturation areas flooding, or with exceptionally heavy snow and low temperatures means solid blocks of ice cave in roofs and disrupt access creating logistical problems for companies… [Construction of] new warehouses are looking more serious, that instead of being built to withstand the one in 25-year weather event, they are looking more at the one in 100-year weather events." – Distillery Operations Officer*

In the other assemblage, in northern Baja California, a local farmer collaborated with one of the firm's field technical operators to develop a micro-tunnel to protect organic crops from sudden temperature variations and local pests. They used low cost materials and local resources and leveraged the skills of multiple individuals working onsite in the field. This infrastructure was co-produced and customised in response to local climate impacts and terrain conditions and capacities.

The plastic and metal structures were approximately 1 metre in height, sufficient to protect growing crops from humidity and heat stress. The local firm employees had the necessary welding skills and the farmer possessed the necessary knowledge to develop an optimal design and protect the crops in that location. This combination of knowledge and resources resulted in a low-cost innovation that was rapidly replicated and adopted by all the farmers in that region.

> *"Local innovation reduced the cost of the [commercial] mesh by 30 percent. We could not start from investing all the retail cost; it started with a local grower. They started in a ranch with low revenue and losses because of disease and pests. They provided some part of the materials and the grower obtained the material for the structure. That was successful and now all the growers close to here have it. In the Vizcaino region, growers considered hurricanes and can roll out the mesh in two hours to avoid damages … We operate differently,*

and in San Jose they invested using government funds and used commercial meshes. They didn't have people with different skills; we put together a team of welders, builders, and farmers. We made our own designs." – Chief Crop Coordinator

The combination of local resources and knowledge allowed the firm to effectively develop and deploy infrastructure that contributed to adaptive capacity of the assemblage through the provision of resources to protect individual farmers' crop and the increased ability of the firm to ensure the supply needed to fulfil sales projects and guarantee their relationship with the market. The interdependence between the focal firm and associate individual farmers provided the opportunity to develop the infrastructure. The firm recognised the importance of the innovation and it was communicated by the field operator to the Director of Operations. This led the action to change from an operational to a strategic vertical integration of the innovation into the business model and resulted in the decision to invest in replicating the structure with appropriate materials across the region's northern supply chain.

The design of the infrastructure was incorporated into business routines, the technical details documented, and the initiative scaled up for replication in the wider assemblage in that geographic location. However, the design was not communicated to the southern locations in the peninsula because internal operational processes compartmentalised and siloes the information, preventing its diffusion across the firm's hierarchical structures. There was no incentive or initiative to transfer or test the infrastructure on southern farms where it was most needed due to the high levels of heat stress, humidity and elevated climate risks impacting the higher value crops. Individual farmers and the cooperative in the southern sites had instead invested in commercial infrastructure meshes 10 metres in height and tunnels approximately 3 metres long, with a complex deployment process. These commercial shaded meshes were intended to manage extreme climate conditions and pests in the field and were tested by firm employees in several locations in proximity to the cooperative's head offices.

The farmers were invited to observe the benefits of the mesh. The tests were successful showing the potential of the new infrastructure to minimise climate impacts from extreme heat on crops. The infrastructure was given to 37 farmers with a history of good financial returns and high performance and installation was done in coordination with the firm's staff. At the time of the research, all shaded meshes and most tunnels had been destroyed by the first hurricane that impacted the region or had been abandoned by the farmers. After the first hurricane that impacted the region, Odile, most of the infrastructure was destroyed because farmers did not have the technical capabilities to rapidly disassemble or otherwise protect the infrastructure from the natural hazard. The structures were exposed, and crops were crushed under the debris, resulting in economic losses for the firm and the farmers. There was a steep learning curve in understanding the technical details of how to properly operate the mesh to prevent pest intrusion and the emergence of disease in plants. In addition, the firm had not accounted for health risks associated with the infrastructure resulting from extreme local climate conditions. Farmers could suffer heat stroke while working inside the mesh, limiting them to half-hour periods for monitoring and harvesting plants after taking time to cool outside the mesh.

The combination of these factors limited individual farmers' ability to monitor crops and efficiently plan their harvest at critical times. The top-down deployment of the infrastructure limited the capacity of the farmers and the assemblage, and furthermore created additional burdens which would have been minimised by using the micro-tunnel design from the northern region. The lower height of these tunnels was better suited to local climate conditions; it protected crops from high-speed winds of the hurricane and eliminated the health risk posed to farmers from the high temperatures, as they could closely monitor crops without going into the mesh.

The design of the initial test explains why the technology was used inefficiently. The technical knowledge to operate and maintain the infrastructure was beyond the existing capacity in the system. The initial tests had been successful because they were carried out in a controlled environment close to the central offices of the firm that were visited routinely by farm experts. This allowed for rapid adjustments and learning loops in the face of any challenges, followed closely by operational adjustments. The farms under more demanding field conditions lacked continuous expert oversight and necessary operational protocols, resulting in inefficiency, failures and eventual crop losses. Frustration among the farmers prompted a retrenchment to accepted, but challenging, growing practices.

"We put more physical energy into growing crops but gain less harvest"

– Farmer in Baja

"The meshes didn't work… very difficult to go in and out, have to open double doors and it is very hot"…"difficult to operate"

– Farmer in Baja

"The meshes only work for them [farmers near the HQ of the firm]"

– Farmer in Baja

In local organic production, individual farmers consider new information or infrastructure as useful when it reduces energy demands and increases the marginal gains of their work. The type of infrastructure and how it was deployed were chosen solely based on economic calculations. Failing to account for the nuances of farm operations meant the action taken was not strategic, resulting in tension in the assemblage later when responsibility for the failure was being discussed. This suggests that the sequence of deployment and the integration of local knowledge and capacity in design are critical to the success of the investments. The pilot project eroded local trust in the use of new resources that could potentially enhance adaptive capacities.

The lack of strategic planning during early design stages forced the firm to later make strategic choices in their operational routines. The firm had to be able to recognise critical information on the capabilities that needed to be developed in order to cope under increasing climate variable conditions. The infrastructure was inadequate for farms in this region already vulnerable to hurricanes and floods and increased their risk due to the dimensions and design of the shades leaving assets exposed to the first catastrophic event, placing additional burden on the farmers. The interviews revealed limited foresight by the firm and a lack of information, which farmers had relied on to deploy the mesh. Considerations when selecting where on the farms the mesh would be deployed ranged from available space to purely aesthetic considerations, so it would *'not look ugly.' (Farmer 4)*

Evidence suggested that some field coordinators and more experienced farmers had accounted for other factors in using the mesh, such as orientation of the structures, historical knowledge of hurricane paths and onsite risk assessments based on the land topography, including areas of potential flooding. These farmers managed to minimise the damage to the infrastructure and repair it after the hurricane. The learning loops necessary to reframe adaptation practices were dependent on the pre-existing skills and capacity of the users, who needed to recognise critical information and solve minor problems to adjust the infrastructure to the local conditions.

The failure to deploy complementary actions, which would require material resources and expertise, impeded vertical integration of adaptation into the firm's model, and limited the ability of farmers to implement adaptive measures. The losses experienced have potentially closed the adoption of similar innovations in the future or experimentation with other types of infrastructure as adaptation options, because farmers lost confidence in the firm's calculations and motives for deploying the infrastructure. Feedback mechanisms or discussions had not taken place on the causes of the failed infrastructure or potential future alternatives.

The inability to incorporate adaptive actions prevented the focal firms from widening adaptation space across their supply chain. Compartmentalisation prevented complementarity in adaptive actions as these could not pass through information exchanges or feedback loops in the firm's assemblages, limiting the development of adaptive capacity. Innovations that altered operational routines, such as locally-designed infrastructure, were possible when firms assessed and documented their effectiveness in locations under climate stress across their supply chain. This required the use of appropriate terms to translate technical language into strategic business plans. Such innovations increased the local assemblage's absorptive capacity, including that of the firm and farmers, by turning technical adaptive actions into economic or commercial value that facilitates its integration into the business model.

Diffusing innovations developed at local sites of operations, such as those observed in both cases studies, required significant investments and adjustments to business routines. The most successful adaptation actions required that adaptive innovations be normalised into strategic routines through a combination of co-production of local infrastructure innovations, local knowledge, onsite resources and capabilities. These factors depend largely on firm capacity and are shaped by business model practices, which can expand organisational adaptation space to system-wide adaptation space. The successful use of infrastructure can improve firms' capacity to make production choices or manage climate stress and build the capital stocks of the firm and its associates. Failed infrastructure deployments, however, can result in the erosion of local adaptive capabilities and further impact different dimensions of trust, incentives and motivation to undertake adaptive action, as indicated by the preceding examples.

5.4.3 Information

Information is a component of strategic decision-making in response to climate impacts. Information can originate and be relayed from different sources in the assemblage, such as reports from technical experts, remote sensing technologies, so-called “boundary organisations” or knowledge brokers. The types of information introduced into the system can be limited by factors related to current business models and economic drivers. The compartmentalisation or diffusion of information within the organisation itself and across the assemblage was linked to key routines and decisions of the focal firm. Developing adaptive capacities through foresight requires timely, coded and curated information that is formatted for the user, who may be a senior planner or an individual farmer.

Table 13 Information as Adaptive Actions

Category	Actions deployed	Contribution	Case
Information	Keeping moisture logs	Continuous monitoring of moisture changes in seed samples to assess risks to crops in the field from rapid climate variation	Black Isle, Scotland
	Farm monitoring	Monitoring appearance of pests and plant disease	Black Isle Scotland/Baja California, Mexico
	Weather stations (raw data)	Forecasting and risk warning for local farmers is improved	Baja California, Mexico
	Investment and demand projections	Foresight and planning	Black Isle, Scotland

In the case of Scotland, business models inhibited the diffusion of information across the assemblage. At this research site, the distillery had not shared any projected demand for barley crops for the following year’s cycle, which affects individual farmers’ capacity for foresight in planning equipment investments, including long-term, multi-year commitments of new infrastructure and combines. This compounded risk by creating additional uncertainty beyond that associated with climate impacts. The limited flow of information detailing the firm's adaptive actions or long-term plans was due to the fear that investors could lose confidence, reducing financial resources. The adaptation officer of the Adaptation Scotland program, explained that working with the private sector has an additional barrier, as the publicly traded companies might be planning for adaptation, but risk financial losses from damaging the confidence of their investors in the business, as future climate risk might threaten the value of the firm.

"There is also the risk of investor confidence as a significant barrier for us to work with them [distilleries]"

- Adaptation Officer, Scotland

In the private sector, the information used to make decisions relevant for climate change adaptation is uniquely shaped by the business model. This creates tension across the firm assemblage as actors have competing interests for how data is utilised to inform actions and resource allocations to develop adaptive capacity. For example, in Baja California, information used to establish the hierarchy of investments in specific locations and distribution among the individual farmers will be shaped by the focal firm's economic calculations, not by the possible adaptation needs of the individual farmers. The Director in charge of planning activities for the entire production cycle,

"We do planning and accounting at the zone level; they [affiliate firms] in turn do their planning and accounting at grower level...The decision to allocate crops is based on experience and productivity, they allocate particular crops to specific growers… Going in and raising efficiency is a cost and places a barrier to doing something like that [raising farm efficiency through direct supervision]."

- Director 1 Firm Baja California

Different types of technical information, like climate data from the focal firm's private weather stations, are used at operational or strategic levels. The raw data requires curation to systematically diffuse it in a way that is trustworthy and usable. For example, the local chief of operations relays information from the weather monitoring system to local farmers when they need to prepare for sudden frosts and protect crops. This mechanism did not require investment, but rather coordination and work with a local academic institution. This demonstrates again how the introduction of new information, knowledge and expertise into an assemblage expands the economic calculations.

"We are diffusers of information."

– Field Coordinator Baja California Growing Zone 3

Informal or shadow system types of relationships proved to be critical in circumventing the limits of proprietary information. The personal relationships and trust between individuals within the focal firm and its associates provided an avenue for the exchange of information relevant to calculate investments and determine the course of action for both parties. In the case of Scotland, communication between the distillery firm and farmers had been disrupted after disagreements over prices, but communication between the cooperative manager and the distillery's Director remained an open channel to relay information on expected demand, technical requirements and direction of operations. This type of information was used at strategic levels to undertake minor adjustments to future business routines.

In the Baja California production sites, the field coordinator had developed an informal partnership with the local research institution to collect and monitor weather station data. This was an efficient mechanism for gathering climate data and alerting local farmers of potential and sudden changes in climate conditions, such as frosts, allowing them to take measures to protect the crops.

"We sometimes need to make massive cuts when there is expectation that a frost is coming. We advise all our growers and we can try to cut the fruit that is ready in case there is damage. Also, it gives time to deploy some preventive solutions, sulphur and water, on crops to prepare for the event"

– Baja California Chief of Production

This type of information rapidly translated into local action by combining precise data with the local skills and capacity of the farmers to mobilise and protect crops, in emergency harvests, this meant harvesting before schedule to have minimum yields. There was no systematic use of information or documentation of the results of this communication practice, or the volumes of crops protected or the losses; rather it was reported in routine radio communications between the production chief, field operations and local farmers.

The local research institution's combination of scientific knowledge and technical skills to curate the data provided complementary capacity to the firm, enhancing their ability to relay information to the farmers. In contrast, in the case of southern Baja California several weather monitoring stations had been deployed, but the lack of complementary resources of external expertise and systematic data analysis meant that no useful information had been collected, nor did the weather stations inform local agricultural decisions.

It can be argued that for information flows to influence strategic decision-making in this type of decisions that present trade-offs in gains and losses, a baseline must be established to identify the value and positive changes in the uses of information gathered from local technologies or through curated data. In other example, in Baja California information generated from testing local applications of innovations, such as water magnetisers or growing infrastructure, had been historically relayed at the operational level through word-of-mouth conversations without any defined format or protocol. This informal practice can lead to adoption and use of information for a limited number of users, but it established a limit to the ability of the economic assemblage to effectively, and efficiently use the information for sustained, long-term adaptation.

"What we would do even if we had data points. And if someone had enough data to say the drought is going to go beyond this year, but the next five years. We would probably start making a triage and change our cropping practices and become way more efficient than we are, maybe setting goals, measuring would be a first part, measuring everywhere we don't measure our water use, that would be a good starting point."

– Baja California Local Operations Director

The projects and changes that align the firm's model with adaptation lack internal or organisational benchmarking. This means that a baseline to track changes and stakeholder involvement is not part of their design. Protocols for data collection must be developed so that senior planners can interpret and codify the information and use the results to impact the firm's business routines. This would require the firm to recognise the changes and investments that contribute to adaptation, and to develop specific manuals and protocols that link these activities to the established business routine, normalising and fusing adaptation planning into business components.

This prompted the firm to learn, improve or diffuse adaptive practices across its supply chain by exploring new ways to incorporate data into organisational routines with a strategic and longer-term horizon. For example, integrating emergency alarms into monitoring activities, logistical planning schedules and response protocols can normalise disaster risk warning into the field teams' practices. Such actions could have improved early warning to farmers and their households in the San Jose region, facilitating the protection of critical infrastructure before hurricane Odile touched down.

This failure to bridge operational routines and strategic planning came down to a lack of strategic communication capabilities. This can be explained by the need for rapid responses to the anticipated immediate impacts of climate extremes and disaster events. The availability of information did not guarantee action. The firm successfully communicated in real-time the extreme climate risk to the farmers by constantly monitoring the trajectory of the hurricane. In the absence of strategic protocols or procedures to protect critical assets, however, there were mounting losses in most of the climate-controlled infrastructure on farms part of the firm's assemblage.

The failure to deploy technical solutions to secure production and dismantle the shaded meshes resulted in great economic and material losses. In the aftermath of the events, it was unclear if any significant changes in procedures had occurred or lessons had been learned. The assessments following the hurricane were reported as being limited to surveying the damage and taking stock of the financial losses. In this case, the firm had not made detailed financial calculations of losses to avoid discussing this with farmers. This conversation had been perceived as potentially problematic and leading to confrontations with the firm. The firm instead decided to move into the new cycle, leaving this as an unresolved issue.

The farmers in Scotland farmers had experienced a similar situation, where feedback on barley quality and varieties were interrupted to avoid discussing the price of crops. This indicates that firms interrupt or change important feedback loops when there is the potential for contestation or renegotiation of existing configurations. It then becomes more desirable to the firm to absorb losses, or maintain a status quo, rather than widening the communication between farmers and the firm's senior planners.

In the same context of information, the lack of a commonly understood format for relaying weather forecasting information within the focal firm created an obstacle for the strategic use of the data in decision-making processes across the firm assemblage. The use of this information at an operational level by the focal firm, where coordinators rapidly deciphered and anticipated extreme weather, limited communication with other departments or individuals within the focal firm that might have recognised the value of this data for broader decision-making and planning processes underway in associated farms and wider host communities.

The failure to communicate increases the inequality of adaptation opportunity for the focal firm, its associates and wider host communities. The focal firm can use this information to make strategic choices on crop varieties, production cycles, harvest volumes and business stability. They can plan in yearly cycles, while farmers can only plan in shorter seasonal cycles and without feedback from the firm's strategic planners, who have already decided on a sales and production volume. This information is critical for farmers to determine the investments, labour and equipment necessary to manage harvests and reduce climate impacts on their grain.

Information resources for developing adaptive capabilities are owned by the focal firm and become modularised between its different operational business units (horizontal), operational and strategic levels (vertically) and the focal firm and its associates. This modularisation of information results in mechanisms that deploy unplanned adaptive measures which fail to incorporate or sustain adaptation processes that can be measured or improved by the firm or farmers. When information was not communicated across the operational units comprising the firm's business model that either performed similar or complementary tasks, the adaptation outcomes were limited to reactive responses and minor routine adjustments. The lack of communication of weather data limited the evaluation capacity of the firm and its farmers and prevented lessons from being learned across the assemblage.

5.4.4 Experimentation, Knowledge and Learning

A critical component of adaptive capacity is knowledge, an outcome of the ability to interpret and organise information (Williams et al. 2015). In the context of adaptation, understanding regional climate change risks and adaptation needs might enable actors to identify minimum thresholds for cooperation, resource use, experimentation and feedbacks, enhancing their ability to mitigate climate impacts. The following Table 14, shows some of the observed adaptive actions in the category of experimentation and knowledge exchanges within the assemblages.

Table 14 Experimentation and Knowledge as Adaptive Actions

Category	Actions deployed	Contribution	Case
Knowledge transfer and exchanges	Genetic improvement on plants and new varieties being tested	Improving local varieties of crops by developing context specific strands with direct transfers to farmers	Baja
	Expert in organic farming and management	Growers benefit from expertise and skills building	Baja
	Coordinators to advice and supervise in production	Growers benefit from expertise and skills building	Baja
	Farm walk rounds	Knowledge exchanges and foresight	Scotland

Learning requires feedbacks to determine where improvements to enhance capacities might be necessary. Understanding the types of changes necessary to manage climate impacts required feedback from the strategic level of the focal firm, including senior planners and directors to the operational level, that is to field coordinators and farmers. The learning loops at local operational sites, such as farms, were interrupted by the failure in the formal communication avenues between the firm, the cooperative and farmers in both case studies. The local farmers were excluded from learning opportunities and knowledge exchanges, like discussions on seed varieties and the quality of the grains harvested in each cycle. This was either because the firm wanted to avoid engaging in discussions on pricing or addressing tensions on issues unrelated to climate stress on production, or to maintain strategic planning discussions in siloes among senior managers.

These feedbacks would have helped farmers evaluate the efficiency and results of operational adjustments made in response to climate impacts. The farmer members of the cooperative had limited access to this information, leaving the assemblage without clear understanding of the effects of their efforts to manage climate stress on the fields the firm avoided opening negotiation on crop prices or discussion on economic or financial matters, to maintain the status quo of economic relationships. The distance created uncertainty on the future direction of the firm's operations and preferences, limiting farmers' ability to plan for investments and undertake longer-term strategic actions that would greatly contribute to local adaptive capacities.

> *"We used to get feedback from the distillery, they would visit us once a year, but since they didn't want to renegotiate prices of the crops, they don't carry out those meetings anymore."*
>
> *– Barley Farmer Black Isle, Scotland*

These interruptions created a gap in learning opportunities in the assemblage. In response, in the Scottish Highlands, where the feedback loop had been interrupted to avoid discussions on prices for crops, a local assemblage of farmers mobilised by local members and non-members of the cooperative uses the 'monitoring farm' practice to walk around and study another individual's farm. This provided an important opportunity and space to discuss farm management choices to protect crops or barns from flooding and other potential threats.

Figure 27 Farm Monitoring Meeting, Scotland. Photo by Author

In both case studies, it was observed that firms engaged directly with farmers in limited ways and failed to provide key information on the results of or value generated from experimentation in the fields with new crops, inputs such as fertilisers or improvements in routines to better manage crops. In some instances, farmers more directly engaged in the daily operations of the cooperative were able to obtain information through the shadow or informal pathway and anticipate the firm's potential directions on varieties of crops or expected demand on harvest volumes.

Local knowledge exchange activities, such as the farm monitor walk-throughs in the community, provided important spaces to collectively discuss production problems and maintain a level of awareness of the general state of the assemblage's different components, such as land quality, new products or inputs for crop growth, emerging technologies or financial resources available, including subsidies.

These spaces were used to exchange information between members of the cooperative and independent farmers, providing a separate space apart from the main economic assemblage and allowing farmers to focus on production and farming techniques separately from business and economic calculations. In this form of walking inspections farmers directly observed and received feedbacks on measures to deal with crop health, asses the efficiency of the farmer measures and compare the responses of other farmers to similar problems.

Another space for knowledge exchanges and learning was created by the government-funded information and research centre in Scotland. The centre provided information sessions, which the cooperative participated in, but did not lead. This provided insight into the potential for locally-led collaborative work to identify risks and avenues for adaptation, as tensions towards the firm and external forces are managed and discussed.

Figure 28 Information Session on Climate Subsidies. Photo by Author

These mechanisms promoted the exchange of ideas among farmers, built trust and placed importance on common problems emerging from climate impacts and disaster risks in their farming region. For example, farmers discussed the location of infrastructure to protect the grain from floods and assessed the effectiveness of investing in certain materials to channel excess water. In Scotland, one of the farmers that had participated in the farm monitoring meetings, explained that in other circumstances, the owner of the farm might have been defensive or unwilling to discuss his or her decisions, but this changed in the context of the learning exercise, where cooperation and knowledge exchanges were paramount to achieving the objective of the activities.

"Here we can talk freely, and no one will be offended."

– Farmer

In contrast, the farmers members of the cooperative in Baja California, these exchanges are coordinated meetings where the assemblages are formed based on the allocation of production resources in zones determined by the firm and the cooperative. This arbitrary grouping of farmers into production zones was observed to be a point of tension and difference among farmers. The observations and feedbacks occurred on the firm's premises, bringing the farmers into a more closely-controlled space for their discussions. An intermediate economic actor with a formal relationship to the focal firm, such as the cooperative or suppliers, mediated these spaces where farmers discussed the experimentation and learning triggered in response to different climate risks. This allowed the focal firm to maintain an operational distance from individual farmers and isolate climate-related risks. The formal mechanisms established long-term partnerships as a component of the business model that allowed firms to transfer the potential impacts of climate to the external actors, who must adjust their own model to comply with the specifications of raw materials and volume established by the firm.

The observed impacts of business model protocols and calculations in delaying or impeding external associates' learning loops suggests that firms can influence their routines by delaying feedbacks. For example, the firm in Scotland had stopped providing feedback to the farmers in their post-harvest meetings as previously discussed. This space for feedbacks used to be considered an important source of information that allowed farmers to adjust their inputs, such as nitrogen levels or size of the grains, and align their quality to the preferred characteristics of the maltster. Limited access to the results and assessment of their harvest prevented farmers from making necessary adjustments and integrating lessons learned in the following agricultural cycle.

Experimentation, innovation and learning processes were found along different pathways in locations where firms undertook economic activities with a variety of local associates. In both case studies, farmers and cooperative officers have a history of experimenting to test new seed varieties in the field and improve internal operational processes to organise raw materials arriving from the fields.

The feedbacks and incentives the firm had in place for their employees or associates were reported as having consequences for continuing to improve or manage direct and indirect impacts from climate or disaster risks, in Scotland in the form of feedback and rewards from the focal firm for the quality of barley grains, and in California was regarding the efficient use of water resources, but in both cases the h the focal firm had eliminated the incentive mechanisms that rewarded individual farmers who exceeded quality expectations, and subsequently the cooperative also terminated this feedback loop because it did not receive any reward from the firm for quality improvement in Scotland, and in California the Directors in the focal firms departments had stopped working to document water efficiency and made efforts to improve water management practices.

The lack of incentives closed potential avenues for farmers and firm employees to better manage climate risks, as this might have encouraged or facilitated diversification or testing of new seed varieties to withstand local climate conditions, or improve technology uses or innovations to manage climate variations on the field. These examples illustrated a change in the firm's operational procedures and relationships to its suppliers that hindered the ability of the system to develop appropriate capabilities to experiment and improve their activities. The CEO of the farmers' cooperative in Scotland, explained the work at the operational level to differentiate and asses the outcome of their actions to improve the quality of the grains, but at the strategic level, this had failed to be translated into a feedback loop to assist the cooperative and farmers to reframe their operations according to the feedback.

"After hurricane Bertha, we divided the barley that was picked before and after, there was visible quality difference, we wanted to see if this resulted in any difference at the production or malting, but we didn't get any feedback from the maltster or distiller."

– CEO of Barley Cooperative, Scotland

The ability to transfer local innovations throughout the firm's assemblage requires not only the strategic mobilisation of resources, but also historical information about the tests and trials that led to those improvements. Failure to redistribute value from local innovations throughout the production system and among similar associates can be attributed to a lack of recognition of the social value of these innovations, and the potential longer-term capabilities that can arise from supporting the initial diffusion among the members of a group of associates or stakeholders.

Knowledge has been identified as a determinant for developing adaptive capacity. According to Williams et al. (2015: p.82), producing or acquiring knowledge requires "*interpreting information and classifying information into evidence-based beliefs about specific phenomena*". In the context of climate adaptation, knowledge enables individuals and communities to make sense of changing environmental conditions and respond according to their desired preferences and benefits (Klein et al. 2014).

Local and scientific knowledge allows actors to participate in climate-related decision-making, and to better understand how to use resources available to cope with climate impacts. Scientific knowledge provides individuals and groups with information and vocabulary to convey their vulnerabilities, and identify which problems arising from climates shifts could be addressed with resources, including finance, technology and information address (*idem.* p. 83). This dimension of adaptive capacity allows actors to shift from short-term reactive responses to climate impacts to investing in proactive long-term solutions.

One form of assembly is created around disaster risk management training. In the north region of Baja California, which is prone to wildfires in the mountainous areas surrounding the farms, firm employees and local farmers had been trained in natural hazard response in case of wildfires. The firm's training logs indicated the number of employees and sessions dedicated to sharing information and developing response protocols in case of the event. In the past, the firm had reported that the rapid response teams and monitoring by farm hands on several farms provided critical velocity to the protection of crop and farm perimeters, as ditches were built and moving chains of employees distributed water. The firm's employees and external supplier farms worked jointly to contain these potentially devastating wildfires.

"We give monthly training on managing pesticides, or new irrigation techniques or products, and fire safety and fire brigade organisation in the field"

– Human resources officers; firm in Baja California

The normalisation of this kind of planning and dedicated resources in the firm's business operations expands their influence beyond the firm's location or physical space. This intertwining relationship with external associates in a direct way becomes tangible beyond economic calculations, helping to create trust and strengthen the relationship with employees based on social and environmental values, which also reinforce the assemblage and build capacity to protect economic gains. The relevance of these disaster management training activities was noted by farmers and the firm's human resources officers.

5.4.5 Governance

The formal arrangements that regulate the farmer-cooperative-firm relationship are critical for shaping agency and adaptive capabilities in the economic assemblage. A variety of formal configurations were observed in the two locations. The focal firm in California established what can be considered a closed configuration of economic relationships, where there is an exclusive relationship between the farmers, the cooperative and the firm. In contrast, in Scotland, an open configuration allows farmers to commit to a minimum contribution to maintain its membership in the cooperative, but to still have the possibility to contract clients externally to sell surplus harvest.

Each formal configuration creates different incentives and motivations for operational actions necessary to advance or create adaptation capacities, such as the adoption of innovation, overcoming short-term views of climate-related problems and moving towards longer-term adaptation planning and seeing the value of cooperation as a desirable adaptive strategy. In southern Baja California, a senior employee mentioned, when thinking about climate change and the firm:

> *"I only think of the relevance of climate change as instilling pressure on the governance system of the firm; we will need to restructure to become more efficient, changing the cooperative structure."*
>
> – *Senior Officer/Director*

Senior officers of the firm recognised that it was not possible or desirable to engage directly with associate farms to improve capacity and efficiency at the farm level. They could, however, create the incentives that would provide space for farmers to enhance their own production capabilities. This would require the firm to allow changes in the legal agreements that have established their exclusivity over the farmers' production and allow them to utilise excess production to seek greater economic gains, encouraging them to increase their productive capacity. This would also improve trust between the farmers and towards the firm's senior management, as they would have additional space to act in accordance with economic incentives and enjoy more independence. These had not occurred as the firm focused on increasing allocation of crop production volumes to high performing farmers as a preferable approach to sustain production, that invest in creating capacities of those lower performing farmers at the farm level.

Trust between farmers and the cooperative was critical to creating an incentive system to improve efficiency. In the case of Baja California, trust in the cooperative had eroded over several cycles. Farmers said this was the result of perceptions that firm and cooperative managers favoured farmers with close personal or family ties to the firm. These farmers would receive higher quality inputs that improved pest control and plant growth and coupled with the perception that lower performing farmers had greater volumes of crops rejected in quality inspection that were considered by these farmers as achieving the required parameters for the market. Some farmers reported this narrowed their incentive to improve production and, as a result, they only worked to maintain a minimum of crop production for subsistence level income.

This situation is connected to both increasing climate impacts and economic calculations within the firm's business model. Losses in certain crops created disruption and uncertainty for the firm's sales teams, which led to a strategy to focus investment in higher-performing farms to maintain production, which reinforced their ability to perform better than other farms. This slowly shifts the economic assemblage, aligning high performers with close economic and social connections to the cooperative as they maintained and enhance. The lower-performing farmers in this shifting assemblage only maintained an economic relationship with the firm to have assured sources of income, particularly given the closed supply agreements. As one of the farmers expressed, having guaranteed minimum investment and income provided by the firm in each agricultural cycle was preferable than moving towards uncertain markets or activities.

"We only stay with the company because we are certain of being paid every two weeks from our crops."

– Farmer in Baja

The investment system of rewarding high achievers with additional production volume guaranteed the firm would meet its targets, but it gradually created a financial trap for farmers seeking to improve their yields. A bad harvest in one season translated into diminished participation in the next one and lessened the possibility of accessing new resources. This resulted in gradually lessening capacity to manage resources among the less well-performing farmers. While opening the assemblage for farmers to move towards new markets would be high-risk for lower performers, maintaining closed economic relationships limited their incentives to improve efficiency.

The combination of these governance arrangements and supply relationships have gradually eroded local capacities to respond to climate- and disaster-related events. The ability of farmers to improve their production processes, invest in new equipment or diversify their crops, can depend on their incentive to create surplus products, beyond those they are capable of selling to the cooperative and focal firm.

However, the closed contractual relationship created a stagnant production system at the marginal level, where the incentives to diversity or increase production were not sufficient for lower performing farmers to improve their capabilities. The gradual erosion of their capacities derived from the cyclical marginal production, but incrementally approaching a threshold of collapse.

In the long run, this is not a sustainable model for the existing firm assemblage. Under the current business model, policing the performance of associated farms protects the value added of these partners for the focal firm, but a potential loss in diversity (geographical, technical or other) from concentrating resources may undermine the adaptive capacity of the firm and its surviving associates. The model cannot continue over a long term because the opportunity costs to the individual farmers to invest time and resources in alternative income generating activities will lead to losses in production capacity in the assemblage.

Furthermore, in agricultural communities where the majority of the farmers and the cooperative members are embedded in the economic and social life of the community, collapsing production in multiple farms or gradual loss of production capacity would create tensions to compete for economic gains with the firm, and lead to more radical reconfiguration of the business model.

A closed business configuration provided the firm with the ability to have formal, exclusive contracts with their suppliers. This meant that farmers could only sell their harvest to that firm. The farmers entered this relationship in exchange for resources and livelihood security. The certainty of agricultural inputs at the start of each season allowed associate farmers to begin growing crops and provided the focal firm with the ability to allocate crops and volume according to its desired configuration and business plan.

The associate farmer gained from this configuration as it was assured steady payments from the focal firm, but it was ultimately placed in a situation of dependence on the choices and changes that the focal firm might undertake. Such changes could include the varieties of crops and the volumes of production assigned to the farm for growing. In the case of production exceeding targets, surplus crop was left on the field for green compost and thrown out at the packaging sites. While processing and packaging this surplus for sale on new markets had been considered as a possible alternative source of economic development for farmers, neither the firm or the cooperative had yet decided to undertake the project due to time and resource constraints.

This type of economic activity could become another form of integration of adaptive actions into the business model. The firm could create value by using this surplus production and enhancing local livelihoods in changing climate conditions. This would expand members' economic activities, widen the community's adaptation space, expand their asset base and change the economic assemblage. However, the closed model created an 'adaptation trap' for low-performing farmers who cannot improve crop production in the assemblage under increasingly higher levels of vulnerability from climate impacts. The focal firm can cover losses experienced by associate farmers to maintain minimum levels of system functions, but, in the next cycle, the focal firm will allocate and focus its inputs and resources on associate farmers that can assure a higher yield according to their historical performance.

Adaptation trap can be defined as:

> *"A mechanism that either deliberately or forcibly prompts accepting trade-offs in response to climate impacts, which result in solely allowing the adapting unit to undertake incremental adjustments to maintain existing functions, but always within marginal levels. This means limiting the adapting unit's ability to accumulate assets, integrate innovations, undertake deliberate forms of adaptation to overcome losses associated to climate change, or develop the necessary knowledge to diversify economic or developmental activities".*

This adaptation trap creates barriers to fostering innovation and exploring alternative solutions to increasing climate related stressors. This means that farmers remain tied to a production system in the economic assemblage at marginal levels, where losses in individual farms are compensated by surplus generated in high performing ones. In the view of the firm, the business model configuration compensates for these imbalances, but at the farm level, farmers and households are in a sense caught in a cycle of assured inputs at the beginning of the growing cycle but reaching only marginal gains to maintain system functions. This 'adaptation trap' could be identified as a barrier to equitable adaptation in the assemblage and considered into a relational view of the business model.

While this approach compensates for the firm's losses from climate and disaster impact by excluding lower-performing farmers from higher-value crops and promoting overall better agricultural inputs in the following cycle. Over time, however, this widens the gap between lower- and higher-performing farmers, contributing to inequality, and gradually leaving certain farmers and households in the trap that requires to them to utilise private resources to compensate for losses, including spending savings from other economic activities or securing employment for a family member in another industry. This illustrates an adaptation strategy of the focal firm based on current business model configurations, with a maladaptive outcome for the some of the farmers. The director of the cooperative explained the rationale of the firm in allocating crops in each growing cycle, where certain growers would receive higher volumes of assigned growing quotes, better inputs and higher value crops.

"The decision to allocate crops is based on experience and productivity, they allocate particular crops to specific growers."

- Director 1

In cases of direct investments by the firm into production, the deployment of material and non-material resources throughout the duration of the production cycle provided critical triggers for operations. This mechanism also provided a safety net for farmers, who could be certain at the start of each cycle that needed resources would be allocated to their farming operations by the focal firm. For example, financial capital was invested by the focal firm and transferred to associate farmers to pay for their labour before these farmers needed to invest in the first harvest or the purchase of seedlings, green compost, drip irrigation tape and specialist expertise. The resources are utilised by individual farmers as lines of credit, which are later repaid by each farmer from income generated during the harvest.

While these arrangements provided a stable and secure economic mechanism for individual associate farmers, they were locked-in arrangements that limited innovation and curbed incentives for improving farming practices in areas where associate farmers were part of a collective governing body, such as the farmers' cooperative. This approach further erodes adaptation capacities of associates by depleting the resources necessary to cope with losses, as firm choices allocate different value crops among associates based on a specific business configuration.

This allocation is determined according to the focal firm's interest to secure or preserve the stability of its business operations. This fails to recognise the potential to be gained by extending the reach of adaptive actions and altering the distribution of resources orchestrated by the focal firm. Over time, if production levels decline, this will feed back into the sustainability of the focal firm and its assemblage. Farmers who were part of the closed cooperative perceived failures in the allocation system of crops, resulting in outliers, marginal farms and lower-performing farmers being increasingly depleted of necessary support and resources. This created the perception of favourable and unfair conditions for different actors in the system, damaging social capital and trust among the community members.

The configuration of the closed system forced individual farmers to narrow adaptation options in very significant ways in response to the actions of the focal firm. The firm's actions suggested that their decisions were driven by compliance with a business configuration established to create or widen their own adaptation spaces. This was the case in Baja California, where the firm's decision to move resources and crops to guarantee economic value limited the farmers' ability to invest in raising efficiency or use excess production to generate some capital for reinvestment into their farms.

This suggests that an open model results in more efficient relationships for the focal firm and potentially for the associate farmers. However, the resources and capabilities that individual associates accumulated were shaped by their ability to be efficient under imminent climate change impacts. It was precisely due to the inevitable shifts in the assemblages, so farmers could maintain their economic functions that adaptive actions and signals delayed the accumulation of critical knowledge or the better use of local resources for innovation. These delays were observed as detrimental to the creation of adaptation space.

The open model identified with associate farmers and their cooperative in Scotland established a minimum commitment in production volumes for the farmers that allowed them to place any surplus harvest on the market. The cooperative established a minimum tonnage of crops for members, where each farmer could commit higher volumes depending on their capacity. By allowing farmers to become members with a minimum, any excess tonnage could be channelled to alternative markets for surplus production at better prices.

Under similar supply structures, the open and closed models indicate different adaptive outcomes. The types of economic arrangements influenced the adoption of innovations and incentives to enhance efficiency at farm level. The social function of the cooperative in the assemblage when farmers were not locked into an economic relationship with the firm indicated higher levels of trust and cooperation. This influenced the willingness of individual farmers to participate in or adopt adaptive measures that originating in the surrounding farms (associate and non-associate) and integrate these into their operations. In Scotland, one of the farmers of the cooperative recognised that farmers had experienced losses and more complex growing scenarios in the region, but they had the assurance the cooperative was looking out for their best interests, as he expressed:

> *"We have trust that Simon and the cooperative do the best they can for us and represent our interests."*
>
> *– Farmer 3*

This was observed in contrast to the perceptions expressed by farmers in the southern locations of Baja California, which were marked by distrust towards the cooperative and focal firm where resources and quotas were deployed in a closed business configuration. In the northern locations of Baja California, however, where farmers are not organised in a cooperative but rather supply the firm independently and directly, adoption rates, velocity, and experimentation were reported as normal and successful business routines. While the institutional context and production processes are very different in Scotland and Baja California, these particular farming communities and production systems share important common traits, were most farmers are second or third generation families, all tied to a single cooperative and growing the same types of crops.

Farmers who made choices more independently increased their agricultural production, supported by the ability to explore additional avenues for economic gains. In the case of Scotland, it was observed that even when sales declined or prices for crops were not optimal, farmers believed that the cooperative worked in their favour to secure the best possible outcome. If any losses were experienced, or unfavourable circumstances resulted, trust in the performance and drive of the cooperative remained constant.

5.4.6 Technology

A combination of technology and firm-provided services informed onsite operational decisions and facilitated coordination in some locations (see table 15 below). The compartmentalisation of technological resources was observed in multiple locations where senior decision makers failed to recognise and integrate these tools into more strategic deployments. Compartmentalising resources in specific departments in this way created obstacles for the firms, limiting their ability to cope with widespread impacts along their resource chains.

Table 15 Technology as Adaptive Actions

Category	Actions deployed	Contribution	Case
Technology	Moisture tests in onsite lab	Provide rapid assessment of the percentage of moisture in barley seeds to plan harvest times	Black Isle, Scotland
	Biological pest control	Continued improvement and search for better pest controls	Baja California, Mexico
	Grain dryers	Increased ability to store grain for longer periods so farmers can sell excess at preferable market prices	Black Isle, Scotland
	Humidity field sensors	Continuous monitoring of moisture levels on the different locations in the plots and field	Black Isle, Scotland

Technical experts and local farmers cooperated in some locations with limited resources in order to make minor improvements to specific operational problems and technology allowed for the rapid resolution of perceived climate stress on routines. However, similar problems in other locations or at later stages in the harvesting cycle were ignored due to the limited incentives for planners, limiting internal ability to communicate the improvements to be normalised in firm's routines. For example, efficient irrigation technologies improved water management in California, but the firm only focused on reducing water consumption in the field during field tests, failing to plan for the costs and incentives associated with implementation across all farming operations.

Adaptation requires firms to use their resources more broadly and normalise adaptation planning into their business routines to enhance their capacity and that of their associates. The diffusion of resources among a wider scope of associates or stakeholders contributed to "absorptive capacity," a firm's ability to convert actions to financial value. In California, the firm in collaborated with a local university to change water irrigation sprinklers and measure water consumption in their farming operations. The project was funded by a local innovation program and implemented by a researcher from the university's agro-food department.

The firm leveraged the technical capabilities and knowledge of the research institution to develop their capabilities, but the project focused on the technical challenges of implementing the water measuring system and collecting information on a real-time basis to inform irrigation schedules. It failed to then codify the information to inform strategic routines. The purpose for upgrading the irrigation technology was not communicated to the individuals involved in the operations and the firm failed to translate the benefits into business calculations. The information generated by the technology was not curated for senior managers, resulting in no added value for the firm and low contribution to adaptive capacity or business model innovation. The production Director of the focal firm in California explained, the senior management staff would receive unprocessed information directly from the water meters, which provided an indication of water consumptions, but this was not usable or useful information. While the technology to collect information that might establish a baseline to measure changes arising of the integration of new technologies, does not guarantee integration into decision making.

"We get raw data but don't know what to do, or how to use it."

- California Director of Local Operations

This missed opportunity of processing data to integrate into decision making processes, was also identified in a second instance, were the Growing Operations Director that had implemented an irrigation project in their local fields:

> *"We started an irrigation pilot, but the field coordinators might not know why, there is no incentive to record changes or we don't get rewarded for savings in water use."*
>
> *– California Director of Production*

The information in those examples could not be aligned with the strategic routines needed for its integration into the business configuration of the firm, such as manuals, procedures or booklets to communicate to internal and external clients, like planners or government ministries, how the changes in water consumptions create value. The low levels of absorptive capacity required the firm to convert benefits into commercial or economic value to leverage adaptation benefits from the technology. This attempt to translate adaptive actions into economic calculations in a business model that does not recognise adaptation resulted in narrow adaptation space through the limited implementation of the technology.

In this case, the field operators lacked an understanding of the purpose of adopting new technologies and did not comply with the technical requirements to monitor and adjust the technology as a result. This showed that adaptation planning in the early design of the pilot project could have provided those at the operational levels with a strategic rationale to improve the efficacy of the pilot and allowed for future replication in other locations. The compartmentalised exercise resulted in some positive outcomes but lacked consideration of how the technology could be used in the future or brought into strategic adaptation efforts at wider organisational levels.

Similarly, in the northern region of Baja California, magnetic water technologies deployed across different farms raised water efficiency, controlled field moisture levels and accelerated nutrient delivery to plants in organic fields. Soil quality was improved by preserving humidity in drier areas and increasing water retention over longer periods of time, reducing the need for longer irrigation. The technology also changed the water's polarity to allow for higher absorption rates and nourishment that improved plant growth.

> *"One producer had water problems, so we decided to try the technology. This was very helpful, but he also noticed that it was not clogging the drip irrigation system in an area with harder water. Another neighbour grower noticed, and while he did not have problems with water, his drip irrigation system was clogging, so he decided to adopt it solely for this purpose. The technology was initially used for water efficiency, but it resulted in having more contributions…and now all our growers have it. We solved water issues in San Vicente region, where we reduced water use from four days a week to only two days' irrigation. We noticed 20 to 30% reduction in water depending on the type of soil."*
>
> – *Baja California General Director*

This technology was similarly introduced by an external firm that focuses on water quality improvements. The magnetisers resulted in unexpected benefits, including increased plant growth and reduced costs by eliminating the need to replace water pipes each cycle. The magnetic technology required little or no supervision, had very low cost and was rapidly diffused among the farmers that observed its benefits. The successful adoption of external technology is explained by the high benefits and low technical requirements in the installation, maintenance and operation.

Despite the enhanced adaptation capacities for several farmers in the region resulting from the technology, it remained largely compartmentalised in the firm's operations department in the northern location, where there was no documentation, integration or communication of its uses to affiliates beyond the specific cluster of farmers in one location. The technology was confined to single-loop learning processes, where routine adjustments in response to climate impacts lead to minor changes in behaviour. Reframing the entire organisation's irrigation practices entirely would have required employees to document the uses of the technology and develop protocols for field operations.

In contrast, in Scotland, farmers' use of moisture meters in the barley fields combined with onsite lab analysis services provided by the cooperative resulted in the ability to determine the moisture levels in different locations of the farm to inform harvest time and sequences. The technology was integrated into the cooperative's routines to inform critical choices with consequences for yield quality and quantity under uncertain climate conditions. During the harvest window, farmers deploy moisture meters in different locations in the field and collect barley grain samples. The samples are then delivered to the cooperative's onsite laboratory services to test for internal moisture percentages. Anything between 17 to 21 percent moisture is considered ready for harvest and subsequent drying process. Above that, it cannot be dried, and lower percentages indicate the barley is not ready for harvest.

The cooperative's use of this information to inform logistics and transport schedules for collecting seeds from individual farmers converts the technology to economic calculations. The climate-related risks of leaving barley grains in the field with high levels of moisture increased during peak harvest season when sudden rain and rapid temperature increases could expand and contract the barley seed resulting in skin damage. This resulted in crop losses as barley quality fell below minimum standards for distilling. The analysis services combined sample collection from the field, onsite technical expertise and equipment to provide farmers with a rapid response and enhanced capacity to undertake adaptive choices to protect critical assets. This combination of resources and expertise generated information for the cooperative that could be used to establish priorities that accounted for diverse biophysical conditions in the fields. The local knowledge and technological resources also helped determine immediate courses of action. This extended farmers' agency, allowing them to influence and negotiate with the cooperative's logistics and transport schedules and developing inclusive decision-making practices. The cooperative created trust in the services, which prevented conflicts from competing priorities of individual farmers.

In the first example, firm managers deployed technologies that contributed to a form of autonomous adaptation response, but the failure to bridge operational and strategic routines limited the efficiency and replicability of this successful use technological resources to manage climate-related disruptions. These barriers to integration silo the resources and benefits necessary to develop adaptation capacity in critical locations in production system. In the second example, the technological resources were combined and integrated into rapid feedbacks to inform local decisions. The technology and information directly shaped decisions related to transport, logistics, storage and risk calculation, providing farmers and the cooperative more control and enhancing their adaptation capacities. These technological actions represented incremental changes to firms' business routines that sought to manage climate-related problems at the farm level, but the investments had very different adaptation outcomes. At the lower operational scales, technology and information were used to improve crop monitoring, management, protection and improvement. At the strategic scales, technology and information enhanced adaptive capacities to the extent that they widened the planning horizon and provided control over decisions, which must account for changing climate patterns.

Conclusions

This chapter identified the forms of adaptive action and the signals that communicate (intentionally and unintentionally) the firms motivations to different actors in socio-economic assemblages. The actions and signals suggested the focal firms business model influenced the adaptive capacities in the assemblage, by acting in self-interest or selecting winners-losers from among the different actors in the same community.

The spatial and temporal control exercised by the firm emerged as some key factors in shaping the relationships and changes from climate impacts, which defined the subsequent adaption choices. The failure of some actors to convert operational innovations into strategic longer-term adaptations is associated with business models that create silos of actions within the organisation. Local responses to manage climate risks remained tied to specific locations of the focal firm's operations.

The deployment of resources solely determined by historical economic performance limited future investments in farmers with lower productivity, which limited their ability or willingness to experiment with new technologies and infrastructure or invest additional resources to develop capital stocks and capacities necessary for adaptation. This cycle of de-investment reinforced pre-existing inequality and created additional risk and placed barriers for enhancing adaptive capacities.

The configuration of the business model also influenced the adoption of local innovations and transfers of technology among the members of the economic assemblage. Neither system was unambiguously positive for associate farmers: one case provided security with stable gains, while the other generated uncertainty but potential for greater gains. Perhaps most important are the long-term implications for the firm's assemblage, with the former system likely to sustain itself at marginal levels and the latter likely to concentrate resources and narrow its membership to provide resources to high performers, with implications for adaptation strategies of the firm and the assemblage.

While assemblages could enhance adaptive capacities through adequate incorporation and diffusion of innovations that contribute to adaptation, the recognition and transference of these innovations to strategic long-reaching and cross-assemblage deployments was impeded by the focal firm's business model. The evidence suggested that a combination of resources and expertise in adaptation-oriented collaborations between the focal firm and local associates created adaptation options by using information and local innovations that allowed for system-wide responses to climate risks.

The focal firm's ability to operate with autonomy from its associates reduced co-dependence and restricted the scope for supportive adaptation beyond that necessary for the focal firm to directly and tangibly enhance its own position. This shows a clear limit to the scope of the focal firm's adaptation to be a vehicle for general social improvement without changing existing business models. The field research revealed two different business configurations with important consequences in the context of climate change adaptation. These forms of organising the economic relationship between the focal firm and associates determined the deployment and focus of resources, the flow of information, the recognition and incorporation of innovations and the adaptations options available for the different actors involved in the system.

The open configuration created formal business relationships in which suppliers could freely operate outside their relationship to the focal firm, whereas suppliers or associates were exclusively bound to provide products and services to the firm in the closed configuration. These forms determined the extent to which the focal firms' responses and creation of adaptation space could enhance or diminish their associates' adaptation space. These configurations had underlying degrees of spatial and temporal features that determined the types of relationships the firm needed to establish to maintain or expand its adaptation space under climate stress. The organisation of business models and relationships in the context of local climate stress was time and location dependent, which led firms to assess a new variety of trade-offs and economic and social calculations to define their membership in local economic assemblages.

In each of the two assemblages contained trade-offs between livelihood security and the accruement of resources to support future adaptation options. As a result, less capable associates or suppliers of the focal firm gradually lost their ability to accumulate resources to invest in the necessary infrastructure or expertise to manage climate risks. The farms maintained a minimum necessary threshold to engage with the firm, however, as economic gains still outweighed the risk of ending that business relationship.

In an open form, the trade-offs for the farmers and the firm arise from the possibility of competing forces in the assemblage, which take the form of competitor firms or emerging economic activities that move farmers towards a different source of income and resources to develop access to information for adaptation. The firm will have to mobilise resources to enhance investments in farmers' abilities, even under an open model, but farmers will also need to develop their capacity to absorb or adopt emerging innovations for adaptation.

In both cases, firms compartmentalised information and resources critical for adaptation. For example, in northern Baja, there was limited diffusion of efficient pest control measures because of the costs of transferring the resources. Another example from Baja was the disproportionate redistribution of resources across the assemblage based on past production performance to stabilise the firm's supply of high-value crops. The firms also deliberately or inadvertently concealed information critical to undertake adaptation options. The distilleries in Scotland, for example, withheld investment plans or the results of adaptation assessments from farmers to avoid creating any perception of risk among their shareholders.

In other instances, firms reinforced incentive patterns that eroded the adaptive capacities of individuals, households or the cooperatives in the host communities by providing farms with sporadic or unregulated investments to overcome losses and reach minimum subsistence level production thresholds. The dynamics between the different areas of the firm, such as production, operations, logistics, research and development, sales and strategy, were configured to maximise profit, reduce costs or comply with regulation. The employees and experts working with the firm fulfilled these functions in the performance of their routines, which limited their ability to create, share and incorporate information in ways that challenged the established arrangements of the model.

The firms' business models mandated how resources, such as technology to improve efficiency at the farm level, were to be deployed or when this was considered an acceptable investment. Intermediary actors, like the cooperatives, reported that such processes were circumvented at times by employees who bypassed the firm's hierarchical organisational structures and worked closely with external associates in localised projects. This facilitated informal cooperation between the firm and less capable external associates.

"We gather information by talking with the director of the distillery; we know what they are planning, but not through formal meetings or discussions" Director Cooperative Scotland

The co-production of innovations or knowledge observed at the boundary of the firm's business model led to incremental adjustments that resolved climate stress and tensions in the assemblage before undesirable reconfigurations of the relationships could arise. For example, the firm in Baja California deployed experts to train individual farmers in the use of moisture monitors to determine optimal harvest days, which made new information accessible to the organisation and its external associates. Resilience was thus built within the assemblage directly at farm level, though economic calculations in the business model did not allow the firms to invest directly in efficiency improvements.

The opportunities to co-produce innovation arose from the increasing pressures and operational imperatives to respond to climate and disaster impacts. The innovations challenged the established functions of the firm by prompting individual employees and planners in the organisation to dedicate resources to adjusting routines affected by recurring climate or natural hazards. For example, local micro-infrastructure was co-produced in Baja California to protect crops from specific types of pests in certain locations.

Transformation, a more radical form of change to business relationships, was also observed at the local scale. In this form of ex-post adaptation, the firm acted to protect the business model's configuration when perceived climate impacts limited economic gains of the organisation. The firm sought to transfer the effects outwards towards the assemblage and its external associates or stakeholders. This mechanism complied with narrow economic interests instead of allowing the firm's business model to transform by integrating or internalising the social or relational factors of adaptation.

CHAPTER VI

Incremental Change, Reconfiguration and Transformation

Introduction

There are degrees of change in adaptation processes, incremental and transformative. Incremental adjustments and changes might be sufficient, individuals, groups and communities will have a limit to adaptation, triggering radical adjustments in the form of forced or deliberate transformation. The concept of transformation has a variety of definitions in the literature, in this chapter, empirical evidence from field research explicitly addresses different scales to describe factors shaping transformational change and provide some examples of transformation.

There are three dimensions to business models – *economic, operational and strategic* – which determined changes in the organisation and members of the assemblages. These dimensions demonstrated movements within the firm's business model in response to signalling from climate stimuli, suggesting how the firm responded to climate stress, providing an insight to how current adaptive behaviour could be a predictor of future adaptation behaviours in the private sector, and the possible outcomes.

In some examples, profit-maximising business models forced other stakeholders into possibly undesirable adaptation trajectories by acting according to the economic driver. The differences between the degrees of change observed both within the organisation and among the stakeholder's part of the local system, suggests the firm's accepted trade-offs that presented maladaptive choices to other members of the assemblage, indicating how the adaptive capacity of local actors was coupled to the economic, operational and strategic actions of the firm.

There is evidence to suggest that co-production of innovations at the local level, and knowledge exchanges among local stakeholders can widen adaptation space for the members of the assemblage and influence the firm's business model that align adaptation responses to a social form of adaptation. In each example, the firm sought to leverage complementary capabilities of different actors, which provided the firm access to skills and resources beyond the established boundary of their business model, and in the process led to changes in some of the dimensions of the business model.

6.1 Business Models and Local Assemblages

The initial hypothesis derived from the literature was that business model mechanisms to engage in adaptation amplify an individual firm's contributions to adaptation. This is premised on the assumption that leveraging the core capabilities and functions of these organizations, more strategic use of their resources is used to develop necessary capacities for adaptation among host communities, including the direct stakeholders of the firm.

However, field generated empirical evidence suggests the configuration of current business models in fact limited the ability of the firm and their stakeholders to undertake planned adaptation. The firms and the members of a production assemblage operating under extreme climate events and changing climate patterns, are operating in a narrowing economic space, where trade-offs are decided by the firm in response to external climate pressure, and internal business demands, where their choices can advance the firm's ability to cope with stress, all the while, eroding or closing adaptation options for different members of the production assemblage.

The empirical data was classified into different changes according to the perceived or observed level of change. The following table 16 proposes degrees of change, according to the shifts and adjustments in response to climate stimuli, that originated in the firm and impacted the assemblage in the host community. In the context of adaptation, firms can undergo: *1) incremental changes in the business model, 2) reconfigurations of business model and 3) transformation of business model*.

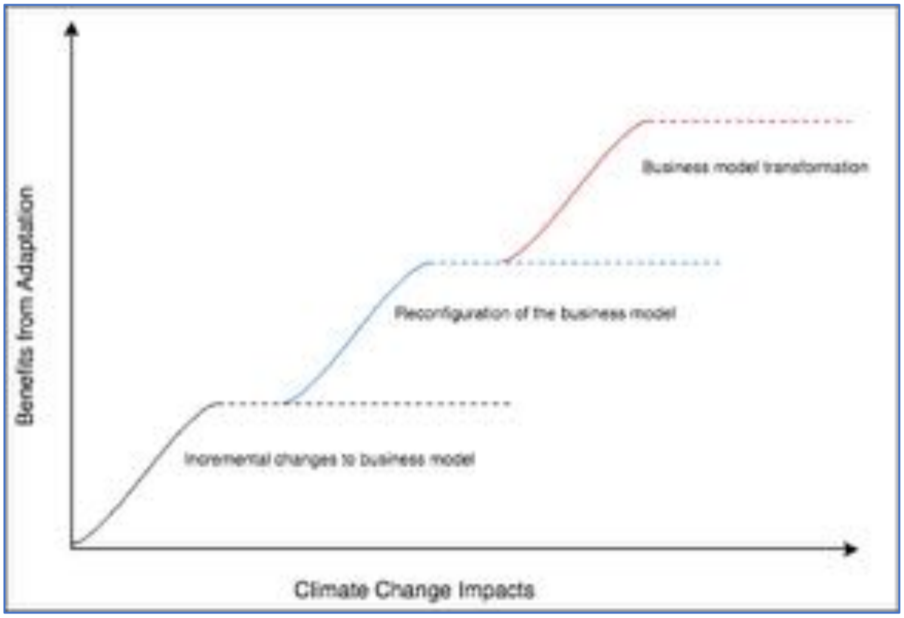
Table 16 Adaptive Changes in Business Models under Climate Stress

Business models and assemblage changes under climate stress			
Type of adjustment	**Description**	**Example**	**Assemblage**
Incremental	Adjustments to operational routines, processes or business cycles	1. Change logistic routes or schedules 2. Increase monitoring 3. Deploy internal experts 4. Leverage cross-department collaborations	Maintain functions, gradual creation or erosion of local adaptive capacities

Reconfiguration	Changes to the organisation and relationships in a system	1. Change suppliers to different locations 2. Introduce new products and technology 3. New services	Observable changes in relationships, practices, locations
Transformation	Fundamental change of organisation's processes, services, assets or system in response to climate change impacts	1. Modify by-laws 2. Create new organisation 3. Integrate social view of adaptation	Change in livelihoods or location

These adjustments can be understood in the firm centric view, were changes driven by the firm will depend on the benefits the actions from adaptation provided to the firm. The degree of changes to the business model, then would be expected to generate different benefits to the firm, and potentially in different forms to a variety of actors in the assemblage. Building on Rickards and Howden (2012) transformative adaptation in agriculture, the degrees of changes in the business model and external assemblages would follow a sequence illustrated in the following figure 30.

Figure 29 Business Model Innovation and Benefits from Adaptation



6.1.1 Incremental Change

The routine or process adjustments in the firm, and subsequent changes in the operational processes of several stakeholders were identified as adaptive actions in response to extreme climate and natural hazards. The firm deployed specific resources and technologies, such as cash assistance for individual farmers for disaster recovery or micro-infrastructure to protect plants during early growth stage from climate extremes, extending agricultural growing cycles or technologies to monitor moisture allowing harvest planning, all these types of actions stabilised or normalised operations after production disruptions, enhancing the ability of the firm or its stakeholders to cope with climate impacts.

These actions created new knowledge and allowed the firm to exert control over their operations, provided new information for decision-making related to future climate risk, introduced financial resources for new assets or delivered as additional income to local farmers to cope with climate related losses after external shocks. These were incremental changes to the firm's operational components of the business model, or to operations and activities of different actors in the host community.

The incremental changes derived from alterations or shifts in the flows of resources, like investments into different types and quality of agricultural inputs like pesticides or use of temperature meters in specific locations, but also from the initiatives and activities of different farmers. Another resource was the provision of technical services to help farmers develop decision-making capacity critical for managing climate-related stress on crops, such as the lab analysis services provided to farmers on the cooperative to monitor moisture in Scotland, or the breeding program of beneficial insects to control pests on farming sites in Baja California.

The incremental adjustments provided temporary solutions as reactive forms of adaptations, trade-offs and tensions among the different actors in the supply chain were observed. The decisions to change the location of a valuable crop or switch pesticides based on economic calculations, for example, demonstrated that certain adaptive actions or the processes for their deployment can create conflicts between business practices and community or stakeholder preferences, and the impacts of current climate extremes can breach the threshold or limit of adaptation.

Incremental adjustments might not immediately alter production assemblages, but they encouraged actors to form or seek integration into different assemblages, including information and knowledge generating groups. For example, a family member may undertake a new economic activity to provide income or join a different sub-group of farmers to manage local resources or better understand practices to manage local climate risks, including understanding infrastructure distribution within the farm. This was the case in Scotland, were monitoring farm activities organised by the agricultural college engaged with cooperative member farmers and independent farmers alike in their knowledge exchanges. In these cases, understanding the rationale for investing in specific assets or changing farming practices, as well as accessing new forms of financial subsidies become a source of critical information for adaptation at farm level.

These *monitor farms in Scotland, then* facilitated knowledge exchanges among farmers on investment decisions. These small actions suggested that, within the scope of internal and incremental adjustments, firms and farmers would seek to maintain current operational conditions to sustain production as a preferred mechanism of adaptive action. Reactive responses provided necessary relief to current climate-related impacts, denoting a level of resilience. The actions could be achieved with available resources, supplemented by materials, information and human capital accessed in their own sphere of capabilities.

However, at times when climate-related impacts on crops or recurring natural hazards disrupted operational routines to the point where minor adjustments or supplies of resources were insufficient, a reconfiguration of sources of value became necessary. This meant a shift or change in the assemblage, including where financial resources were invested or technology was deployed. Reconfiguration within the firm and among associates or stakeholders was observed only when such alterations to the assemblage were in the firm's interest.

The next section describes observed reconfigurations, and those that are expected as the firms' business models continue to operate under increased climate change pressure without incorporating or normalising adaptation planning. Incremental adjustments to business routines sustained firm functions under climate stress. The cumulative effect of these incremental changes was a later reconfiguration of different components within the organisation. The failure of such responses was a broader reconfiguration of the assemblage, which had observable effects on associates' adaptive capacities.

6.1.2 Reconfiguration

The reconfiguration of the business model and external assemblage is the result of second loop learning. These types of actions reframed the components that constituted the system, thereby changing the sources of value and information among the assemblage members. This mean, that the focal firm shifted the distribution of capital and knowledge exchanges as a mechanism to overcome the limits of incremental adjustments, and sustained the income generating expectations created by the existing business model. This is trajectory in some sense is forced on the firm, by the existing architecture of the capitalist seeking business model, one which has not, or cannot account for a social view of adaptation.

In both case studies, among the members of the assemblage beyond the focal firm, the cooperative and farmers focused economic efforts on maintaining a business relationship with the firm rather than expanding to new economic activities or markets. The economic relationship established between these actors, made it preferable for the members of the supply chain to maintain acceptable losses than to move towards higher levels of uncertainty.

The initial business configurations used to exchange information, resources and obligations are structured to support and achieve desired system functions depending on the specific characteristics of the supply chain necessary for economic gain. Firms can engage with suppliers in different locations, for example, to source part of their supply of a specific crop from farmers located in regions with micro-climates favourable for early harvests, which can increase the market price.

The configuration is composed of the diverse associates and suppliers directly or indirectly linked to the firm. The different business configurations described in the previous chapter denote their relevance to organisational and supply chain adaptation. Reconfigurations have different trade-offs for firms, as they could create the possibility of competitor firms influencing clusters of farmers associated with the assemblage.

The influence over the assemblage to create more favourable conditions required the firm to invest time in developing new relationships, make longer-term contractual sourcing commitments to specific locations limiting its adaptive options by creating narrower sourcing locations. The widening configuration to bring in new sources of supply in climate stable locations represented an increasing but necessary business risk.

While the time required to establish new supplier relationships in different, more stable locations with lower levels of climate risk represented high operational and opportunity costs for the firm, which outweighed the levels of investment required to develop the capabilities of local farmers in their established supply chain. This trade-off revealed the tension between the reality of climate risks and current business configurations, where adaptation planning has not been integrated into business strategy. When longer-term adaptation planning is not factored into business model calculations, the risk is delayed or transferred, as the risk of encountering the same trade-offs in new locations in the future remains.

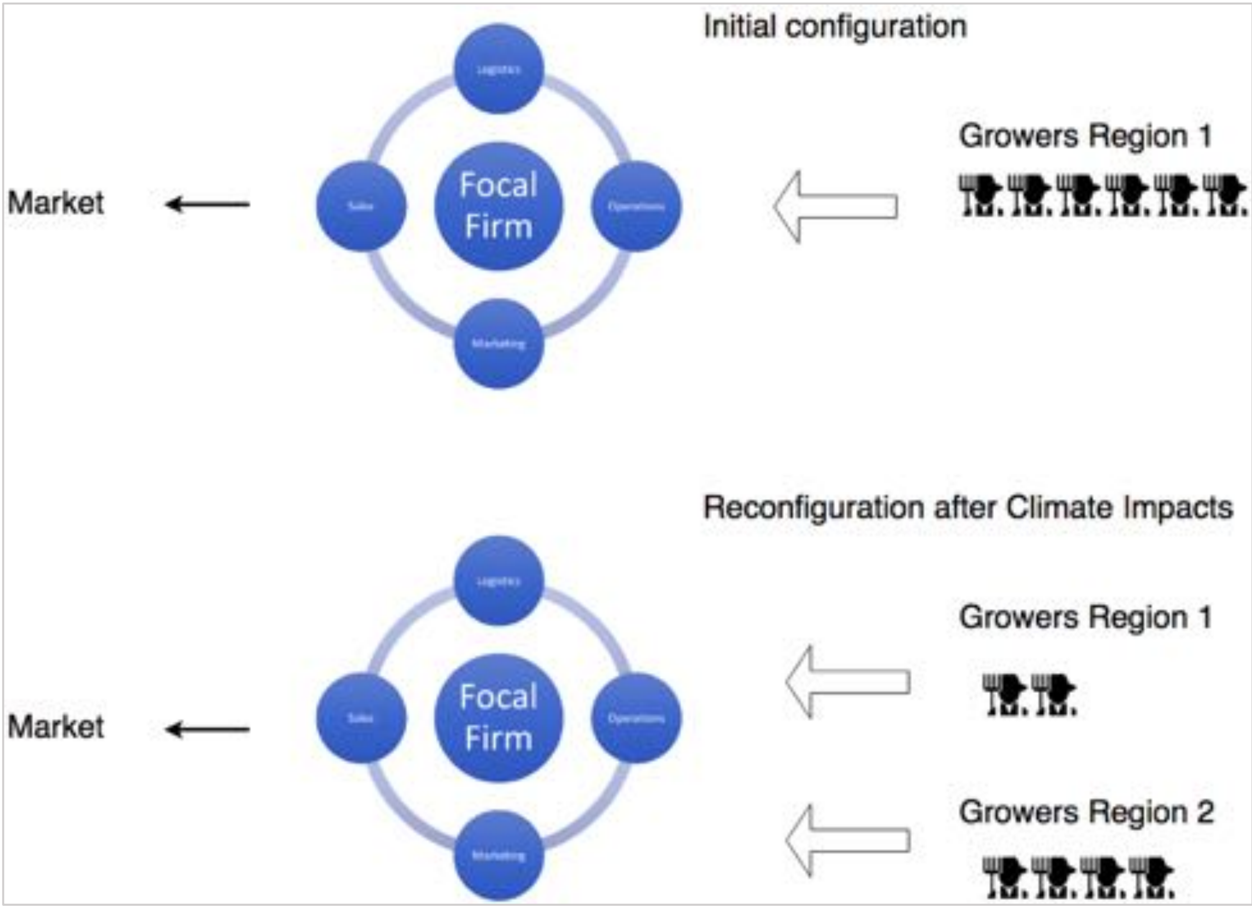
The disruption of stable financial relationships can have long-term impacts on the local community associates and stakeholders. The consequences of abandoning local suppliers in order for the firm to reorganise their business operations elsewhere could be devastating to local adaptation capabilities. The shifting resources and suppliers is a prime example of a change temporarily benefiting the firm to the detriment of the adaptive capacities in the local community, as resources for new assets and competition for diminishing economic opportunities can collapse the community.

The reconfiguration is expressed in the shifts in the relationships and resources of the firm. The literature on business models does not address spatial or temporal dimensions of business model configurations. The empirical evidence showed that spatial and temporal factors embedded in firms' business models are central to economic calculations and strategic decisions. These might remain decoupled from adaptation, however, even when they become evident dimensions of business planning in climate-sensitive sectors.

The business model is configured to minimise risk, avoid costs and seize opportunities to attain different forms of value. In the sectors studied, each of these objectives are directly influenced by changes in physical climate parameters. The access local associates had to information, resources and learning opportunities was observed as linked to the configuration of these arrangements, shifting according to climate and disaster impacts. Creating adaptation space for the firm while preserving its ability to extract financial value or avoid increasing costs required adjustments beyond incremental changes.

Such changes were observed to diminish the adaptation space for other members in the production assemblage. The dimensions of firms' business models exposed to climate stress revealed information on the necessary adjustments and provided insight into the potential consequences of shifts in routines. Mapping adaptive actions across the dimensions of a firm and the locations in which it operates might reveal what actions will be taken and whether they would close or create adaptation space for local associates. Figure 31 below shows a climate-driven reconfiguration observed in Baja California Sur growing locations.

Figure 30 Reconfiguration of the Business Model



The observed changes are beyond incremental adjustments. The initial configuration in shows a supply chain providing inputs to the firm, which can occur either directly or through a cooperative. Increased climate-related impacts, including shifts in average climate during harvest windows or in the intensity or predictability of natural hazards, impacted the flow of the supply chain, affecting the firm's ability to sell regular crop volumes on the market. When incremental adjustments to relationships and supply patterns became insufficient to cope with the impact of recurring climate-related losses, the firm reconfigured the business model to extract value from different locations and routines, as shown at the bottom of the figure.

In Baja California, the reconfiguration was triggered by incremental losses in crop production from climate related impacts, mainly the appearance of plant disease and fungus on organic basil, combined with failed deployment of the infrastructure needed to provide a greater degree of control over changing climate patterns and facilitate decision making on growing operations. This combination of factors, including climate related impacts, drove the firm past the threshold of acceptable incremental change, including maintaining farmers at marginal level of production.

This reconfiguration allowed the firm to draw crop supply from different locations and growers and reduced its investments in the original group of growers. This resulted in decreased income levels and new tensions with the local farmers that created pressure on the firm to maintain previous production levels. This presented the firm with a trade-off that could be resolved either by substituting the types of crops planted in that location, investing to raise the efficiency levels in the first location to source the desired volumes or leaving the farmers with marginal levels of production and hoping for improvement the following cycle. The evidence suggests that once a reconfiguration occurs, it does not return to the original arrangement, which means the emergence of the new assemblage, with more stable characteristics under increasing pressure from climate extreme, provided the firm a way forward past the limits of existing in adaptation in one location, where the configuration might shift towards the same sites again.

As climate impacts move closer to affecting core business operations, there is a greater likelihood that reconfiguration, rather than minor adjustments, will be necessary. This means that production disruptions would prompt the firm to protect operations and secure its volume and supply, while factors like crop prices may not pre-empt such action. More extreme actions, like establishing new supplier relationships in alternate locations to safeguard the firm's supply of specific crops, resulted in losses for the cooperative and the farmers in the Baja locations. These choices also became undesirable to the firm, as they had to find new suppliers and renegotiate agreements with longer-term commitments to secure the necessary supply. This also opened the possibility for competitor firms to incorporate individual farmers who had been part of this assemblage into the supply chains of new economic assemblages.

"We have cross department meetings, but we don't really discuss climate change, some of them have, but in case of downy mildew (first crop impacted by climate) that created an agreement, 30% is the unofficial rule that we developed for the basil in Baja, but applicable to other zones [that no supply area will exceed that level of supply for the company. Which might become dependent on new areas of growers.] …These areas are no longer able to produce as they used to with the rains and humidity… ***So yea we had to reconfigure that relationship.*** *It is a push and a pull, they would prefer to supply us with 90%, but they can't and we can't rely on them to do that, so we need to look for new suppliers or existing suppliers."*

- California Director of International Operations

The incremental change of allocating crops differently represented an internal shift in the firm's assemblage. This meant that parts of the firm shifted their resources, expertise and logistics to increase farm-level efficiency in locations guaranteed to provide the required supply. The second form of more extreme change shifted the external assemblage of associates, as it moved the supply chain, routines and investments towards new locations. Direct associates and indirect stakeholders, such as farmers' families and field workers, were affected by this change. These two distinct re-arrangements denote the shifting assemblage of resources. In the first instance, the firm's internal components rapidly realigned their operational and short-term planning cycles to perform desired economic functions. In the second, a slower process is underway, which is directed by strategic calculations with longer planning horizons and has lasting consequences for the community. Shifting risk by seeking alternative supply chains is a normal business process that diversifies the business model.

The first type of adjustment aligned operational routines by shifting investments and resources to focus on high-performing farmers. These adjustments had consequences that caused minor contestation among the suppliers, where some farmers viewed the firm as providing preferential treatment to some farms. However, as some farmers lost production volumes, the high-performers in the community-maintained production capabilities. This signalled to the lower-performing farms that increases in efficiency would be compensated by the firm through increased investments and allocation of crop volumes in the following cycle.

"They [the cooperative and company] give all the best fertilisers and expensive value crops to just their close farms and friends."

- Baja California Farmer

In the second form of adjustment, the reconfiguration of the assemblage created direct contestation and resistance from the cooperative and member farmers, as the reduction in the region's allocated crop volumes equally affected all members of the farming community. In such case, the cooperative's role was to manage and negotiate with the firm to compensate for the diminishing volumes, either through substitute crops or increased investments in infrastructure to raise farm efficiency for the next cycle. These actions illustrated how the cooperative and focal firm tried to create adaptation space by changing and reassembling routines and relationships to manage climate impacts. Through this, the firm protected its supply, but it eroded the adaptation options of their local suppliers by narrowing the sources of local economic gains for the individual farmers and their households.

The farming cooperative navigated these changes assessing individual farmer performance to maintain a membership of farmers able to produce steadily under increasing climate stress. The tensions among the farmers, or between farmers and the firm, revealed the imperative of balancing business model configurations without losing the operational capabilities developed in the region. The firm recognised the risk of competitor firms co-opting farmers that had lost production volume allocations, which left them to re-calculate whether to raise farm-level efficiency or dismantle part of the production assemblage. Such trade-offs shaped adaptation processes at all levels: farm level, cooperative level and firm level.

> *"There is a tension with the growers, as they are trying to take as much of the pie as they can, where we are trying to diversify at the same time. When we say diversify, it's the same crop from multiple sources. When the growers say diversify, they mean more crops in the same place. That is where we need to come to the table and come to an agreement with them. A constant in every season is agreeing on a plan that works well for that zone according to the sales forecast."*
>
> *- Baja California Field Chief Coordinator 1*

The cooperative lost production volumes and individual farmers were affected directly by the losses in income from reductions in high-value crops. Shifting basil production from the southern region of the peninsula to northern locations occurred over a five-year period, steadily reconfiguring a business model that had been in place for 30 years to diversify the supply source. The reconfiguration of the business model due to climate-related stress stopped, slowed or distorted the assemblage's functions and created tensions between growers and the firm, as both tried to gain from the harvest and minimise losses.

The climate impacts and shifts in harvest windows are highly likely to increase in variability. This will aggravate tensions when the firm seeks to adapt by reconfiguring their supply to come from alternative sources. The reconfiguration could also compound the risk of diverse firms operating in the same climate region with different crops as pests have been transferred from different regions to one location, were climate patterns magnified the impacts. Early communication among new members to these types of growing clusters or locations, would provide valuable information to control plant related vectors of disease from different climate regions, as well as more direct involvement of researchers and experts to convene competitor firms in spaces that allow for technical discussions focused on common problems in production, not those related to financial gains and competitive advantages, both related to the components of business models, *"There are regions were growers are in the middle of the different primary growing areas. These zones have companies from different nearby regions producing during growing windows, as weather patterns in their areas of origin do not allow them when it's too hot. However, because these areas are used only for this window, producers don't invest in infrastructure, such as nurseries and bring in their seedlings along with irrigation and other materials from their places of origin. This resulted in diseases and pests combined from all productions zones on the northwest region. It created a complicated growing environment in an area with difficult conditions that has only begun to be controlled."*

– California, Production Chief, Jacobs

The firm's production targets determined the allocation of specific crops and volumes to the cooperative, and subsequently to individual farmers. The allocation of higher-value crops and resources as reward to high-performing farmers gradually established a structure over various cycles that closed the possibility for lower-performing farmers to make efficiency gains. Climate change's impacts are not considered in the planning and execution of the firm's business routines. The increased variability in climate patterns, diminishing water resources and increased intensity of natural hazards are considered inherent risks to agricultural production by firms and farmers. Still, a failure to recognise needs as climate-related was reported in various locations, despite some individual farms already having been relocated due to water scarcity and certain crops being shifted to new regions due to extreme climate conditions making them no longer viable for cultivation.

"[We don't know if its] directly related to climate change, but that premise let to the consideration that we will be having more storms in the eastern pacific and having all production in the Baja is a big risk, because it seems in previous cycles hurricanes were periodic, but infrequent now it seems with higher frequency."

- Baja California General Director Firm

The adaptive actions necessary to reduce climate-related impacts have remained embedded in siloes within different business routines of the firm, the cooperative and farmers. These actions remained unrecognised or undocumented in strategic or deliberate response protocols. Climate and disaster impacts, however, have continued to shape and change agricultural practices along the supply chain reorganising small portions of the assemblage in each agricultural cycle.

In the case of Scotland, these types of reconfiguration had not yet occurred, but the drivers of potential changes were present in the system, such as considering alternative sources of resources for the primary crop, limits to the use of current technological assets to improve harvests such as combines and the narrow option for the type of seed used across the entire farming assemblage, which was only one variety.

6.1.3 Transformation

The means-to-end conceptualisation of adaptive actions provided empirical evidence of changes in the firm's relationships. Different examples suggested that transformative changes occurring outside of the firm that are driven by the firm's economic calculations can radically modify the production assemblage. In the case of Baja California, the firm supported farmers' preference to relocate to maintain farm-level production. The relocation of farmers and their families allowed them to maintain the same economic functions, indicating a transformational change in the assemblage. This furthermore required a repurposing of land and the conversion of productive economic assets.

The different interpretations of transformation require specificity of scale to distinguish this type of change (see Chapter II). An incremental scale towards transformational change in the agricultural sector was presented as a result (See Figure 1). This section builds on that scale to describe transformational shifts and advances the analysis through empirical evidence that links scale to business model drivers. In these cases, the observed outcomes illustrate the potential for certain adaptive actions taken by the firm to be viable adaptation options that have transformational consequences for the associates of a firm at the individual, farm and household levels. This could include changes to economic activities, the location of farms and the location of family homes in the case of small farmers.

This type of movement had consequences for the adaptation trajectory of the assemblages, as firms had established certain adaptive actions. Under current business models, adaptive actions taken by the firm can predict their economic and operational preferences when determining courses of adaptive action in the future. Firms had to take deliberate action to avoid severe impacts on their business operations when farming was no longer viable for certain farmers due to depleted water resources from slow aquifer replenishment or increasing demand from urban centres. In the case of organic crops, this kind of climate stress is rapidly damaging and especially noticeable in tomatoes, basil or fruits.

Adaptive actions like altering crop varieties, nutrient management, crop spacing, and planting times are part of ordinary routines that are adjusted every year in this type of agricultural production. A second-tier type of adaptation actions, such as precision agriculture and diversification, are also being implemented by the firm. Despite this, the risk in growing organic crops proved high due to water-related stresses and extreme climate variations in the traditional summer harvest period. As a result, transformative forms of adaptation were observed in farms on the fringe of the firm's operational boundary, either in terms of geographic location or production volume.

"Pea production was no longer possible in the Ensenada region, we have at least two families that relocated to the central south valley in the peninsula. We had to relocate various families in the region, water was not sufficient to grow crops anymore, we [the firm] had some available land further south in the peninsula with water and offered them to relocate to continue farming"

– General Director, Del Cabo, Baja California, Mexico 3

This was transformative type of adaptation considered by the firm and the farmer as a win-win situation, which reveals the potential influence and capability of business models in shaping adaptation trajectories of individuals and households. The transformative adaptation emerged from a deliberate reconfiguration of the assemblage and the business model's boundary in a context where the local climate and resources became increasingly unpredictable under climate change impacts. The firm identified viable options by analysing their land inventory and matching farmers to the land use designated for organic production. The firm planners calculated that the cost associated with production losses was higher than that of relocating the farmers, as minimal capital investment was required to maintain system functions and crop production volume for the next cycle.

"We looked at land further south in the region, and proposed they move."

- Baja California Director of Operations

The action preserved the family's livelihood, which was preferable to losing their economic activity in this case. However, this would have implications for social capital and their ability to leverage the complementary knowledge, information and support provided by a community associated with the longer historical ties that would have been developed over time with their peers, households and local institutions. This example illustrates the possibility of families or small businesses within the boundary of influence of a firm's business model being presented with adaptation options driven by the preferences to maintain a business configuration, where the firm maintains the expertise, skills and capacities of the farmer to grow specific crops by offering relocations to a new lower climate risk site. This is possible by the accumulated assets and geographical distribution of the firm's land base, which remained a type of grid where the business model deploys and extracts value.

The assemblage on the other hand, would be affected through the repurposing of land, the movement of families' part of a community to new locations and the redirection of resource flows, which become forms of adaptive behaviour driven by individual firms. This represents a shift or erosion in the system, both legitimizing the move as a viable adaptation measure, but also splicing the assemblage without losing the desired production functions.

6.2 Signals in the Assemblage

The preceding sections established the ways in which material resources shaped adaptive capacities by directing investments or deploying technology with direct influence on a production assemblage. The organisational adaptation model (see Chapter II) proposed that firms would react to market and climate signals when internal learning processes were triggered that led them to codify information, undertake experimentation, resolve routines disruptions or seize opportunities arising from changing climate patterns. These changes are further influenced by the normalisation of adaptation into business routines.

If seen through the assemblage perspective, material resources are just one of the components of assemblies. The connections and flows of information between the assemblage's members and generated by material resources demonstrated how firms can also act as emitters of signals within the assemblage, which can be relevant for adaptation. The degrees of change and adaptive actions send different messages to members in the assemblage depending on their relative position to the firm's operations. The organisation undergoes learning cycles and readjusts its routines according to the signals it interprets from climate impacts, in the form of production disruptions, or from the market, in the form of new opportunities to create value. The adaptive actions the firm takes in response send different messages to their associates or stakeholders.

The signals sent by firms' adaptive actions suggested that their actions can influence elements or processes necessary to develop adaptive capacity in their assemblages to different degrees. This form of influence might be overlooked when the focus of analysis is solely on material resources and tangible forms of resources. Associates can interpret the signals as the firm is undergoing a downturn in production cycles, which can trigger competition among suppliers to secure investments or access information on the firm's economic strategy. The following Table 17 provides some examples of different events that were observed to have high signal value for adaptation, which amplified or attenuated elements of risk through the firms' responses to climate-related impacts.

Table 17 Routine changes with potential high signal value

Business routine changes with potentially high signal value		
Event	**Location**	**Message(s) to associates**
Firm absorbs farmers' crop losses and suspends collection of infrastructure credit payments	Baja California	These are stable and normal routines that do not require changes even if climate-related losses have been experienced
Ignore mesh destruction and absorb the losses	Baja California	Lack of lessons learned; the firm has resources to subsidise the farm; no need to learn from event or improve infrastructure; wait until firm decides what to do; lack of accountability
High yield in plots belonging to family members of someone working for the cooperative or firm	Baja California	Corrupt practices in the production system; preference to certain farmers; lack of transparency
Suspend farm visits and discussions on crop quality and future crop varieties	Scotland	Disregard for supply partners; no importance placed on feedback; isolated or disjointed
Do not provide feedback on quality tests	Scotland	Disregard for outcomes and results; disinterest in local efficiency improvements
Rapid response to moisture test by firm laboratory	Scotland	Support and attention to individual farming conditions

Field officer calls on radio all farmers in each location before a frost arrives to advise them on taking protection measures for crops	Baja California	Support and effort by the firm to collaborate beyond formal arrangements to support and protect farmers

The consequence of signalling competition to community members eroded trust and solidarity among farmers. For example, in the case of Baja, the allocation of higher crop volumes to specific farmers created the perception of favouritism by the cooperative towards specific farms owned by family members of the cooperative's managers. As one of the farmers in one of the more remote locations explained, there was a perception that certain farmers were given preference as the cooperative protected their supply chain and assured crop production by focusing more efficient pest control measures to those with close ties to the firms administrative and decision-making bodies. This made sense from a perspective of the business model, as quotes for certain crops narrow, the cooperative selects those farmers that have either the capability to grow higher yields, or those that have established ties that link them to the cooperative beyond a contractual relationship. As it was stated before, second and third generation family members from the original farmers were now part of the cooperative administration but continued to have family managed land in the supply chain.

"They [Cooperative/Company] give all the best insecticides and seeds to their close [family and friends] farmers, and to the rest they give us only preventive measures that don't do anything for pests."

– Farmer Baja California

The shifts in the allocation of growing quotas signalled competition to the farmers to secure resources. This was reinforced by the uneven allocation of the more sophisticated agricultural inputs, such as high-performing pesticides and new infrastructure, to extend production in specific high-performing farms. These practices created a locked or closed adaptive system where innovations or local adaptive actions concentrated in a small number of producers, which led to decreased confidence among the firm's assemblage.

> *"We get a bit into company politics…my job is to make sure we have enough supply, so whether it's coming from our regions or growing zones, is secondary to me. It is more important for me to keep the warehouses supplied than giving priority to different growers or different zone."*
>
> *– Baja California Cooperative Production Supervisor*

These signals are received by external members of the assemblage when operational routines shift, or the firm takes strategic actions to manage crop volumes. The signals could change if the shift in the firm's action was the incorporation of adaptation planning into business model routines. The messages sent by this action would be more likely to improve the assemblage's ability to work in harmony to strengthen system-wide adaptive capacities, supported by a stable flow of resources.

> *"If we could develop a two- to four-year rotational plan with all growers, with the sales team, that is more linked up and we can do that in each region, ideally it would be different enough that you have no competition with each other. From the production area, we would need historical yield data, pricing information for different commodities at times of the year, cost per acre, cost of production."*
>
> – *California, Focal Firm General Director*

Another signal to direct associates was *dependence*. In the Baja case study, this was found to cause long-term operational problems for the firm and trigger internal tensions between operational units and management. Several examples emerged from the firm's desire to maintain stability in production. The historical or community ties that were disrupted by allowing change to occur caused unnecessary uncertainty within the firm's adaptation space. The firm's adaptive decisions to act or avoid undertaking radical shifts were made under the assumption that existing socio-economic conditions would remain at constant levels of manageable uncertainty and costs within acceptable parameters.

The assemblage maintained fixed and stable functions but were limited in scope of actions they could take and still faced fragile conditions. Directors in Baja observed these signals. When farmers were unable to maintain efficiency due to climate-related shifts in their production windows, but they did not adjust harvesting practices and periods accordingly, it ceased to be possible for the firm to achieve profits. Regardless of this, the focal firm continued to purchase the crops and to maintain a relationship with the associate farmer suppliers through the cooperative, so keeping the farming system functional until the next cycle. For example:

> *"The company in the north takes a very paternalistic stance towards the farmers, it is a very American way of helping, saying – We are here to resolve all your problems – and it has become an uncle and nephew relationship… the company in the south they are doing the best to make things happen, but when they can't, the company takes the stance of we will just do this for you … there have been situations when they lose the crop and the company ends up buying crop even if we are not going to sell it. They often don't see the consequences of planting in wrong windows or more, it has been happening for so long it is assumed to be an obligation almost."*
>
> *– California, Production Director*

The instances of absorbing crop losses revealed the firm's acceptable level of cost, but there were exceptions. The deployment of climate-control infrastructure without proper protocols or consideration of local farmers' socio-technical capabilities resulted in severe losses during hurricanes. It was observed that no attempt had been made to calculate the losses or ascertain what proportions would be absorbed by individual associate farmers and by the focal firm several months after the hurricane. While subsidies could be interpreted as support to the farmers, there were some negative effects of these signals. Farmers avoided making changes or experimenting with potential solutions to climate change-related impacts. Should the firm remain committed to maintaining this level of support in similar instances in the future, the signals to develop further adaptive capacities through subsidies would be overshadowed by the firms practice of temporarily resolving the disruption. It has been observed that losses will eventually exceed the capacity of the firm to absorb, which will lead to magnified future risk and impact.

Finding the balance between the signals for stability and adaptation under climate change is proving difficult. The firm remained tied to the principle of stability even though adaptation may be increasingly more important for the long-term sustainability of the firm's assemblage. While past actions might have been interpreted by farmers as the economic decisions of the firm, under climate impacts or disaster events, the decisions of the firm are interpreted as maintaining functions at the expense of the local community. This can lead to a loss of social licence to operate in certain locations. The firms and its associates would have to commit to advancing common adaptation actions to provide the members of the assembly the opportunity to interpret climate-related losses under a common scenario.

"There is a real correlation how we react as a company instead of trying to find alternative solutions for those [lower performing] growers that are being affected, we are accommodating their situation to our needs, as opposed to fixing our needs despite their situation. We are reacting the wrong way, we are solving the issue for them, but creating a bigger issue for the company."

– California, Production Director

Each adaptation action observed or experienced by any associate or stakeholder of the firm will contain a message or signal, which will influence the actors' decisions to continue or potentially change a behaviour that could contribute to adaptation. The relational approach to firm adaptation proposed in this thesis provides the basis to identify the actors, resources and signals that contribute to shaping the adaptation spaces for the assemblage. From this view, the signals relevant to adaptation are no longer just received and processed internally by the firm. Rather, they may be redirected outwards toward other actors, amplified or supressed in compliance with the business routines and capabilities of the firm and its associates, who assign value to each of these signals.

The actions described in the previous sections include process changes, decisions and adjustments to the configuration of the business routines. These are concrete actions by a focal firm, which can be clearly observed by different local actors and prompt a variety of responses. A global scan proposed a primary categorisation of these signals, and several additional forms emerged during fieldwork. The examples that follow all arose during the field research. This is not an exhaustive list of signals, but a proposed analytical basis to explore the influence of individual firms on specific actors in the context of climate change adaptation. The function of the firm in the following examples oscillates between providing individual adaptation spaces for the firm and collective or social adaptation space for other members of the community.

The descriptions emphasise actions that triggered signals which influenced individuals, groups or specific organisations in the production assemblage. The consequences of adaptive actions are thus amplified at varying scales, with possible further effects in the future. As a complementary dimension to the adaptive actions taxonomy, the Table 18 below of signals from adaptive actions provides an additional analytical component to private sector actions under climate stress, particularly those that have consequences beyond the organisational boundary of individual firms.

Table 18 Recognised signal patterns from adaptation actions

Recognised Signal Patterns from Adaptive Actions		
Signal type	**Description**	**Example**
Cooperation	These actions signal to external actors the firm's willingness to cooperate through resources or expertise in climate change adaptation activities.	Holding a forum or commissioning a joint adaptation analysis, in cases such as the Scotch Whisky Association. This signalled to competitor firms a willingness to cooperate to mitigate climate impacts.

Competition	This signal to associates or supplier's competition for resources in the same geographic location and members of the same supply chain.	When a specific volume of high-value crops will be assigned or allocated to individual farmers in a single region, capping the volume at 30% of the overall supply signals that farmers need to compete for allocations
Dependence	These signals emerge from actions that indicate to associates or stakeholders that climate- or disaster-related losses will be subsidised or absorbed by the firm.	Subsidising the losses in crops due to climate events without feedback or corrective measures required to prevent or compensate for these losses.
Indifference	This signal originates from actions that have consequence for information or resource pathways but are ignored or not communicated disrupting feedback loops.	In Scotland lack of feedback on exemplary quality of crops; in Baja infrastructure losses, conflicts on water use among farmers ignored.
Dominance	This signals the firm's intention to overtake or appropriate adaptation resources or adaptation spaces.	In cases of limited adaptation options or trade-offs, aggressive firm behaviours to dominate potential adaptation spaces through deployment of resources or experts, or policy favourable solely to limited actors in each location.
Stability	These actions signal deliberate efforts made by the firm to maintain functions and system stability across the assemblage, through focus on performance or reinforcing vulnerable or exposed units.	The firm offers to establish supply partnerships and rely on long-term agreements that place sourcing responsibility on their partners.

Adaptive actions can signal cooperation to achieve common adaptive goals. For example, partnerships for climate adaptation projects that successfully support local initiatives or experimentation with new technologies can signal to competitor firms or local governments the firm's ability to identify value in adaptation. In another example, the Scotch Whisky Association, which assembles most of the distillery firms in the

Highlands and Islands of Scotland, commissioned a study to explore climate risks and possible adaptation options for the industry.

The firms in these locations have established historical relationships by trading inputs for their production and strategically cooperate on issues critical to the industry. This signal was not amplified beyond the firm to reach individual farmers, who could have undertaken individual actions to assess their own risk in the face of climate uncertainty. The firm contained the signal to avoid shareholder perceptions of risk, which would have potentially created investment instability and loss in confidence in the industry or at individual firm level. In climate adaptation activities, cooperation with individual firms is limited to a shared interest in advancing objectives, protecting gains or achieving specific outcomes. While important for public perception or common opportunities to advance adaptation processes, the signal of cooperation with individual firms is limited by the requirement for confidential processes in business operations.

"As an industry, on the production level [firms] are very collaborative, and the reason for that is that companies do trade with each other, they buy, sell or swap product to construct different blends. On a production level, there are common issues that it makes more sense to act together as an industry and have critical mass and more resource efficient for successful outcomes... On the marketing side, they are as competitive as any other business We feel we need to do this for our survival, we are ahead of the game, we feel it is important that we try to understand what needs to be done now to sustain the industry in a 20-plus year timescale."

– Black Isle, Scotland, Research Institution Officer

Cooperation occurs among distilleries, but farmers have perceived indifference signals from the reported interruption of feedback loops pertaining to their performance. Trials or experiments in the field to improve crop quality and management of potentially damaging climate-derived risks can go unrecognised or unrewarded, which can lead to potential avenues for adaptive options being abandoned. In the case of Scotland, indifference by the firm to the farmers' and cooperatives' achievements led to a loss of experimentation. There had been a historical relationship in which farmers were provided feedback on their efforts to improve quality. The potential for farmers to pursue actions that improve efficiency to overcome climate-related risks is still present, but the attempts to undertake incremental adjustments when indication of successful trials was abandoned.

"We stopped when the distillery didn't give us feedback, our efforts or quality was not recognised, they stopped coming because they didn't want the price of barley to come up for negotiation again."

– Farmers' Barley Cooperative Manager

These types of signals received from actions do not reflect any responses to positive adaptive activities of the firm. The potential to undermine actors' or associates' efforts to experiment or incorporate practices that could help develop adaptation capabilities are limited by the firm's distancing or interruption of feedback loops. This was reinforced by pre-existing notions of the firm's behaviour towards its stakeholders. It was found that silence through inaction, or actions that deliberately intend to interrupt change, signalled indifference on the firm's behalf towards local activities. This example illustrates that the business model configuration to increase value requires the firm – in this case the distillery – to avoid renegotiating prices, with the consequence that it interrupts potential innovations in local farming practices that might lead to increased adaptation options.

While these actions can sustain associates or actors within the boundary of the firm's model, they can lead to increasing distrust among the members of the supply chain and perceptions of unfairness in formal relationships. In the case of Scotland, it was observed that senior officers from the firm and cooperative communicate routinely through informal pathways, which has helped maintain stability and the sense that actions were conducive to efficiency improvements in the production system.

"We talk almost daily, [CEO of cooperative], we've known each other for years, we informally exchange information on quality and purchases including potential problems arising with farmers or production of the crop in the year."

– General Director Distillery

In this case, the role of the cooperative's leader was central to anticipating potential frictions between farmers and the distillery. However, a potential change in leadership in the cooperative could lead to an interruption in these informal mechanisms to resolve tensions arising from production. Under increasing climate and disaster risk in production routines, the loss of historical or personal pathways that help circumvent conflict between the firm and actors within its operational boundary but have not been developed into formal feedback mechanisms, combined with continued actions that signal indifference, could become a variable leading to fragile and vulnerable relationships.

6.3 Business Model Boundary and the Focal Firm Assemblage

The boundaries of the focal firm were conceptualised in the analytical framework by proposing a set of basic relationships where resources, business routines and information flows determined a focal firm's scope of influence. Business routines describe the techniques and practices that control the flow of resources and information across an assemblage of actors. These routines can shift or change in response to a variety of climate stimuli. Changes can either be sudden dramatic impacts, or more gradual onset changes in response to climate pattern variations.

The different internal components of the firm's business model include financial resources, research teams, production teams, sales, logistics and transportation, which are all linked to individuals, groups and organisations through a complex web of relationships. Power, information and resources can shape (and determine) adaptation outcomes. The extent to which resources and relationships allow the firm to extract value has been determined to be the conceptual boundary of a focal firm's business model. For example, a focal firm's investments in irrigation equipment or seed varieties become products that are delivered by the logistics and production teams' routines to farmers on a variety of production sites, where the firm later will draw value in the form of crops. The firm's transportation costs, schedules and routes will also be determined by the location of individual farmers or suppliers.

While the business model's boundary can be conceptualised through the formal relationships and resources allocated through the firm's operational routines, the assemblage has no identifiable boundary. The focal firm's direct associates are both part of its business model and of a broader economic assemblage. The firm may not have a central position in the assemblage, as individuals, land, resources and information flow in and out of it in different moments, locations or forms. For example, in Baja California in some of the farmer's households, certain individuals focused their energy on growing and harvesting crops for the firm during an agricultural cycle, but they engaged in different economic activities in a different season, introducing new resources and skills to the assemblage in the next cycle.

In the Black Isle, Scotland, the farmers purchased equipment or shared machinery sourced from various locations or sold their excess crops to producers not directly connected to the firm. This indicated a greater degree of independence, which was possible due to the type of contractual arrangements with the cooperative. In this production assemblage, the contracts did not require farmers to exclusively source the cooperative and focal firm, but only committed to a minimum crop volume each year and over the minimum the quantity was self-determined. This flexibility was a critical difference between the two cases, which had important implications on the farmers ability to share information, accrue new assets or decide over production decision each agricultural cycle.

In the following paragraphs some examples of sub-assemblages are used to illustrate how information, technology or resources can trigger changes or innovation. They suggest how members in the assemblage seek complementary capacities to those provided or limited by the focal firm where the firm's business preferences and configurations exert greater influence.

These local sub-formations of individuals or groups had valuable knowledge and information that complemented certain operational capabilities or helped circumvent the barriers to creating adaptation space. Such limitations or trade-offs were created by the adaptive actions of a dominant firm. This suggested the relevance to adaptation of innovations beyond the firm and tensions between actors in locations where the firm deployed investments or resources.

The expansive property of the business model provided a mechanism to examine both inward and outward exchanges of resources to explain the connections between business drivers and adaptive capacities. The analysis of the organisational adaptation space widened by examining the influence of economic agency on adaptation outcomes beyond the firm, where adaptive actions were used to normalise operations disrupted by climate stimuli that threatened economic functions.

The firm's embeddedness in the social and economic life of its host communities through the individuals in the organisation and groups in the supply chain revealed the capacity of a dominant economic agent to influence the ability of these communities to cope with climate extremes. For example, in the southern region of Baja California, most farmers' family members were part of the firm's economic agricultural activities, either as suppliers, employees or field pickers. In Scotland, multiple family members all provided crops to the same cooperative in their small community.

The firm becomes an agent of change by extracting or allocating resources in different locations through its business routines. The related activities can include providing specific financial investments, deploying water irrigation or remote-sensing technology, retrofitting infrastructure, protecting critical assets, or increasing the presence of highly-qualified human resources to maintain or create value under climate stress. The connections of the different business model components to a variety of local associates and stakeholders in the case studies suggested that exchanges of information and resources shaped the capacity of the firm and other members of the assemblage to cope with climate impacts.

The firm mobilises or limits new investments, flows of information or expertise through established business norms, practices and routines that are determined by the configuration of the business model. This configuration is organised or assembled to maximise value for the focal firm. For example, regular farm inspections by agro-experts can result in the deployment of additional pest management services to maintain or raise farm efficiency in locations where climate impacts have reduced crop volume if economic calculations indicate financial gains for the firm from investing in such an activity.

An array of resources and information are created and re-distributed within the organisation and along the assemblage to maintain economic functions, and the chosen distribution limited the formation of adaptive capacities by suppressing information or unevenly distributing certain resources. A broad view of the local assemblage suggests that adaptive actions steered by business model drivers accommodate the firm's preferences and values and reveal or conceal adaptation options for associates and stakeholders.

The asymmetries in the assemblage point to the presence of unequal relationships between firms, farmers, cooperatives or institutions where members have different capabilities and access to financial resources, expertise and social capital. In some cases, actors will have limited power and autonomy to determine or shape their own adaptation space or will move towards an assemblage with more capable partners. However, in the cases of smaller firms or organisations, such as individual farms, local assemblages might be formed that operate in a more equitable manner. Financial capabilities are less important factors guiding in the formation of these assemblages, with cultural and social values having more influence.

In the case of Baja California, for example, older, respected farmers contributed to shaping the assemblage. In Scotland, this role was similarly filled by the Director of the local cooperative, who was a prominent local figure holding a historical legacy of relevance to the community. In a socio-economic view of adaptation by an assemblage, dominant economic agents have the potential to develop or gradually erode the adaptive capacity of local individuals, groups or organisations. Their actions strategically compensate members of the assemblage for climate-related losses, create opportunities to substitute sources of economic gains or share local innovations that enhance the firm's or associates' adaptation capacity.

6.4 Innovation: Co-Production, Adoption and Diffusion

Adaptive actions are forms of innovation. They encompass new processes, technologies, information and resources that facilitate adaptation to climate change and extreme climate events. The deployment, use and distribution of the value of financial, technology or information will depend on the alignment or contestation between firm and associate interests and drivers for adaptation. The different degrees of change with or driven by business models suggested that innovation can provide a control mechanism for the firm and its associates to move from forced changes towards desirable changes in the context of adaptation.

The benefits of adaptive actions are distributed in proportion to the degree that adaptation planning was considered in their deployment. Current business models were found to present several challenges for integration. Firms limited their associates' use of resources to create new assets, the climate information they received and their ability to participate in decision-making necessary to undertake adaptation.

The unique combination of resources, expertise and knowledge made available by the firm depended, on the firm's accepted functions. Functions were not renegotiated due to changing needs across the firm's many relationships, but because of business drivers within the firm itself. Potential exists for new functions to emerge under climate change that facilitate the redistribution of resources available at the boundary of the business model where firm operations interact with external associates. Members of an economic assemblage must recognise challenges posed by increasing impacts of climate change on local social and economic processes early to gradually shift the conditions in their favour.

Across the supply chains studied, successful innovations and technologies enhanced the adaptive capacity of the firms' economic assemblages. These included the locally co-produced innovation using local skills and materials, which resulted in micro-infrastructure to protect crops from climate stress and disease in Baja California or the introduction of magnetic technology to increase water efficiency on the fields, and the retrofitting with a co-design of external experts and the cooperatives officers of the dryers that provided cost savings, or the moisture meters and testing services provided by the cooperative in Scotland, These were successful forms of innovations, in the design, the materials, operations or processes that assisted farmers, cooperative and focal firm in better coping with the impacts of climate stress.

Their direct associates revealed that adaptation had been an early consideration in the design of on-site pilot projects developed by farmers and firm employees. The shift from operational to strategic action resides in the change from short-term to longer-term cycles. Extended planning cycles are necessary to understand the potential impacts of climate and disaster risk in operational locations. In local assemblages, identifying a purpose for the deployment of resources widens the scope for cooperation, as this allows other actors to provide support for the achievement of a mutually beneficial objective.

Integrating adaptation into planning requires firms to consider codification of information and local capabilities. For example, in northern Baja California, weather antennas were installed that generated and relayed data from the monitoring institution to field operations and, subsequently, to local farmers in the form of a curated synthesis of alerts or instructions to protect from sudden changes in temperature. The sequence of purpose, technology and use organises the activities across different locations, allowing adaptation action to be understood by all members of the firm's assemblage as a common response to climate impacts. This form of cooperation suggested that it is possible to enhance social adaptation space.

Co-producing innovation required learning and participation in the design and the use and feedback of new technology, processes, information and local knowledge. Within the observed examples of co-production of innovation, the adaptive outcome was rapidly integrated into business model calculations. Successful adaptation measures led the company to vertically communicating these innovations across their structure through procedural or technological mechanisms. The adjustments, materials and people involved in developing local infrastructure and innovation were described to the senior planners of the firm in a manner that included social and economic calculations. Communication pathways were opened between lower operational scales that led to the integration of successful adaptation actions into longer-term investments at the strategic level of the firm.

The successful combination of local knowledge and technical skills prompted adjustments to business routines. The innovations allowed for greater foresight and the empowerment of different actors. In Scotland, for example, the cooperative developed their capacity to store grain and sell it when market prices were optimal, enhancing their ability to negotiate. Local innovations were observed at the intersection of the boundary of the firm's business model and the sphere of another agent's activity, such as a local farmer. Innovations led to wider adaptive spaces for both actors. The related firm reconfigured its model during the next cycle after recognising and converting useful operational routines into strategic actions. This resulted in enhanced benefits through the transfer of resources, improved processes or creation of new knowledge. Each benefit could inform future adaptation decisions of the firm and its associates in specific locations.

Contrary to the hypothesis that core business capabilities enhanced the firm's contributions to adaptation, it was observed that flexibility was critical to the integration of adaptation in business models. Firms had to be able to recognise novelty and allow associates the space to develop alternative responses to climate impacts. Examples of niche innovations being cooperatively developed or adapted from commercial to farm-specific specific uses, within the business model's boundary, were observed in several locations along the supply chain in Baja California. Experimentation remained confined to specific geographic locations primarily due to the firm's limited uptake of the innovations, which meant these could adaptive actions could not be deployed in other locations along the economic assemblage.

While this could be explained by the pace of the operations and lack of resources, the issue was actually seen to be the firm's failure to document or measure improvements that could be translated into savings or value. Not accounting for what the literature calls "absorptive capacity" limited the resources and time the firm allocated to supporting the diffusion of these innovations, including infrastructure and magnetic water regulators.

The focal firm has a critical role to play in adopting and diffusing material innovations or information across its assemblage. These actions could lead to further innovation resulting from new combinations of local expertise and technical and scientific information introduced by the firm. The firm failed both in integrating resources into their business configurations and promoting the use of potentially beneficial resources across their assemblage, which could have provided incentives to employees and associates and enhanced their capabilities to utilise new technology or interpret information.

To draw value for the firm by protecting crops and extending harvest cycles, local innovations required the mobilisation of human and financial resources and close monitoring of the technology or infrastructure. This was reported as necessitating personal exchanges of information and feedback between firm employees and farmers in both cases studies: in Baja in the case of mesh infrastructure and in Scotland with the barley dryer in the cooperative. The failure to redistribute value generated by innovation throughout the economic assemblage could be attributed to limited capabilities for long-range planning. These innovations required that information be de-modularised and combined in new ways to support long-range investments. The firms' rigid internal operational routines were also observed to undermine potential experimentation with new technology, as occurred in California and Baja California with hydroponic installations and in Scotland when firms selected specific barley seed varieties for the farmers.

Innovation in the assemblage is not only shaped by the speed of resource diffusion, but also by the sequence of distinct components of the assemblage. Economic drivers take precedence for firms when ordering their assemblies, but further from the firms' core operations, it was observed that different drivers led to the integration of different resources. At the boundary or periphery of the firm's assemblage, considerations of expertise and capacity complemented resource efficiency and economic calculations, which seemed to propel technological or innovative action. Coproduction, learning and integration drove adaptive actions when actors discovered mechanisms of complementary that enabled them to bypass barriers erected by business model economic calculations.

In the past chapters, the adaptive actions taken and their beneficiaries (see Chapter IV) provided indications of the rationale behind firm's deployments of resources. However, closer analysis of relationships suggested firms can encourage the formation of clusters of high-performing production relationships to resolve climate change-related disruptions in their operations, creating trade-offs within local adaptation avenues. Economic agents have the potential to influence assemblages through materialities: finances become actions or needed resources, and local capacity and information are converted into innovations.

In some cases, these processes dominated adaptation space and created barriers for smaller agents like family farmers and households to undertake desirable responses to the external stimuli. Indirect stakeholders became sources of information or the beneficiaries of temporary relief provided as part of the firm's operational strategy to overcome climate-related disruptions. The adaptation assemblage was therefore influenced by the trade-offs and tensions that arose between firms and direct associates when different adaptive actions were undertaken. These tensions surfaced when adaptive options highlighted opposing interests within the assemblage that required a renegotiation of economic costs and benefits to correspond with adaptation needs under increasing climate stress.

Actors were found to draw value from adaptive actions commensurate with their pre-existing capabilities and relationships. This suggested that an uneven distribution of the benefits from adaptive actions created greater disparities in the adaptive capacities of the focal firm, its associates and stakeholders in specific places. This has important policy implications, as current adaptation finance might create organisational adaptive capacity while overlooking the importance of building local capacity. Emphasis on the latter objective is necessary for some members of an assemblage undergoing climate impacts to maintain their economic or social relationships.

If assemblages collapse or shift towards assemblies with similar capacity levels, efficiency and financial would shape local trajectories in more uniform assemblies. Lower-performing members will almost certainly be excluded from new formations, locking them into an economic or adaptation trap, or forcing them into a different assemblage with new social and economic agents. Regional adaptation policies could target investments and create incentives to encourage firms to normalise adaptive actions in their relationship-building processes and identify and invest in local adaptive capacity. Developing such policy mechanisms would require consideration of current failures and future directions of adaptation.

For example, a low performing farmer having lost crops regularly to extreme weather events or crop disease from variations in weather patterns during harvest, and over time mainlining the exclusivity contract with the focal firm to receive agricultural inputs and fixed prices for crops, or not being able to decide the type or varieties of crops, maintaining his growing function but operating at marginal levels. The farmer that accepted the conditions of the arrangement, precluded him from seeking new markets or introducing new crops, limited financial gains and those accumulated remain at risk of being lost under a first impact of climate associate changes. While the farmers operate at this level trading potential for deliberate adaptation for secure or continuous flow of minimal income or resources to keep farming operations.

The resources deployed by the firm are sources of information. The outcomes of the firm's adaptive actions provided formal or informal feedbacks to Directors, Managers and local beneficiaries on the utility of technology, infrastructure or financial resources. The feedback can be converted into new activities or routines in future business cycles when the information has been recognised and normalised into operational or strategic activities.

The normalisation of adaptive procedures means aligning disaster risk reduction and climate adaptation activities into the design and deployment of new resources, deliberately opening adaptation space for the firm and its stakeholders. This can assist the firm or the farmers in protecting existing assets, extending production cycles or supporting local adaptation at different scales along the supply chain. Decisions to introduce new assets or information into the assemblage can drive or limit change within the organisation or its associates, such as weather data, estimated crop volume allocations for the next cycle or market prices estimated by more sophisticated climate risk models available to the firms.

The failure to recognise and diffuse innovations transferred climate risk to local producers in the supply chain. The evidence suggested that not articulating and codifying adaptation needs into business model routines limited firms' and stakeholders' ability to develop adaptive capacity. Resources could not be combined in strategic ways to extend planning horizons without an understanding of actors' needs. In closely interdependent supply assemblages, the overlaps and complementarity between business models of different actors resulted in actors in the upper levels of the system shifting climate risks to lower scales. The business model dictated that a partial collapse of certain locations of the assemblage that recurrently drained the firm's resources was an acceptable form of adaptation option to stabilise overall functions.

6.5 Economic Assemblages and Adaptation

The business model is a system-level concept, which can provide a map to identify where organisations changed and improved adaptive functions through innovation. Understanding the different routines that undergo shifts in response to perceived climate change impacts provided evidence on the types of changes firms made to expand their adaptation space. This required firms to create the necessary conditions to pursue the desirable course of action to maintain economic gains under climate stress.

The routines designed to deliver material resources suggested firms could influence various processes and practices of the individuals, groups and households part of their economic assemblage. Further, a firm's business configuration shaped and shifted the arrangement of the assemblage, either by providing members with new information, investing resources, repurposing land or developing, sharing and deciding upon the uses of technology. Climate change impacts forced firms to contract the boundary of their business operations to preserve business stability, limiting their ability to pursue independent adaptation. To do so, firms had to reduce the resources and information provided to operations at periphery of their model, either geographically or financially. Firms seemed to calculate that it was preferable to reshape their operations and focus their investment in locations that have proven to maintain value under climate stress. This created trade-offs for local suppliers who lost their ability to sustain production. The alternative option for firms was to deploy resources and raise efficiency in line with the adaptation needs of their associates or local actors when this investment was preferable to changing relationships with suppliers. By doing so, they could avoid potential risks from shifting operations to new locations or ending long-term relationships with their associates and stakeholders.

The configuration of the business relationship held until the disruption to business routines necessitate a response beyond incremental actions, moving closer in geographical or strategic interest to the core of a firm's operations. This diminished the firm's ability to deploy resources or extract value, surpassing the acceptable cost for efficient adaptive actions. The levels of climate extremes and disaster-related events are likely to increase over the following decades, challenging the firm's ability to veil their impacts through minor re-configurations or actions that signal a sense of stability. For example, providing direct or indirect subsidies as a normal corporate practice to maintain the current status quo, filtering out the degrees of climate risk on agricultural production.

The actions undertaken by firms ripple across a variety of scales. The amplification of risk by the firm's business model does not derive from specific disaster events, but the observations suggested that marginal shifts in the business model to manage climate stress can gradually increase vulnerability to climate change impacts due to inappropriate responses, lack of incentives and inability to open adaptation options within the assemblage. Current configurations of business models can limit adaptation and adaptive capacities by reinforcing underlying development failures in each location. Dominant actors within an assemblage can restrict the flow of information and resources necessary for innovation in local adaptation processes due to their inability to recognise the value in cooperative planning for adaptation. The empirical data suggested that firms can extend their influence by diffusing information and resources among their associates, removing current constraints. For example, when climate information used to inform preventive measures is broadcast beyond direct suppliers, or the efforts of multiple farmers are coordinated to control frosts on crops in sudden weather shifts.

The preferred adaptive actions of the dominant economic agents in an assemblage create a form of adaptation regime. They shape adaptation spaces by targeting resources or information towards locations and individuals that can provide value to the firm. The inability of business models to incorporate socially cooperative adaptation measures that recognise climate risks affects the coping capacity of local economic assemblages. The evidence suggested that adaptive actions seeking to sustain revenue streams and maximise profit deprived actors in the assemblage of adaptive options by limiting the resources available to invest in adaptation or forcing them into certain productions patterns with increasingly higher degrees of risk.

The personal and organisational relationships between the firm and suppliers can be enabling and generate co-dependence, or they can be ambiguous. Adaptation responses test and shift these relationships to accommodate different values of collaboration or competition. The focal firm's organisational structures were reconfigured in response to a variety of climate change-related risks and impacts. When responses were undocumented or uncategorised, the transfer of climate-derived risks to suppliers through firm responses seemed likely to become firm routine. This was observed to be an automatic response driven by the limits placed on the firm's internal departments' ability to exchange information or innovations with their associates, which are necessary to develop adaptive capacities.

In the assemblages, information and resources moved along formal or canonical pathways that established the firms' investment schedules. They also determined the extraction of value from their suppliers, by allowing the firm to arrange the location or select the crops according to preferred sales components and projections. In Baja, crops were selected according to climate conditions. In Scotland, crop varieties were selected to allow the firm to produce a greater volume of the spirit. These decisions limited farmers' market access as the firm determined the type and quality of its preference according to its business model. These formal or canonical pathways also provide alternatives in themselves for the firm, such as the possibility of establishing longer-term agreements with cooperatives or similar intermediary organisations, like maltsters in the case of Scotch. These options allowed firms to draw value through secure sources of raw materials and to transfer risk by assigning different obligations to the intermediary organisations.

These formal pathways seemed to inspire investors' and firm planners' confidence in their own ability to lengthen the horizon or timeline necessary to plan or undertake adaptation options. These canonical pathways as opposed to shadow or informal pathways created certainty by providing permissible spaces to implement more comprehensive investments or activities that led to greater adaptive capabilities of the firm and associates. However, these spaces tended to arise between the organisation with strategic capacity and planning potential and smaller or less capable actors. Smaller farmers and growers were found to be excluded from information regarding the firm's longer-term arrangements or partnerships to secure inputs, regardless of their origin, therefore hindering their ability to draw potential gains from these agreements needed to invest or plan in longer-time cycles. These investments and pieces of information were required to test innovations, draw greater value from current infrastructure or create certainty in the stability of their economic relationship to the firm.

The focal firm's business model was configured to leverage external capabilities through partnerships and relationships with long-term perspectives that enhanced their ability to manage climate-related problems. In the production of Scotch Whisky, the distillery-maintained stability in the supply of malted barley over long periods of time through business partnerships with strong intermediaries, like the cooperative and malting companies, that transfer the responsibility for securing raw materials for malting to these external actors.

"Security and supply is paramount to us, that is why we have a relationship to maltster…We give [maltster] specifications and tonnage, they are responsible for their supply and tonnage and quality."

– Distillery Manager

Business partnerships allowed formalised adaptive actions to be taken through a mechanism that stabilised disruptions to business routines and transferred risks through contractual obligations to the suppliers or external associates. These agreements have significant consequences for associate farmers when information is not diffused, preventing them from adjusting production volumes. When focal firms formalise partnerships and interrupt the flow of information to the farm level, individual farmers lose important feedbacks loops from the focal firm by distancing themselves from the field operations. The intermediary organisations, such as cooperatives, play a critical role in mediating or buffering the risks by deploying different resources to farmers.

Building the capabilities of the distilleries required long-range planning. This included information provided by experience from historical institutional memory, not limited to current climate events. The skills and processes required to undertake changes were informed by technical expertise that enabled the firms to understand the risks emerging from changing climate patterns in the region. The local farmers, with shorter planning horizons and skills limited to family capabilities and experience, were unable to visualise longer-term strategies. Any new information or knowledge was often introduced by organisations or local exchanges with their peers, as it is explained in the knowledge creation sections below. Lacking in longer investment horizons was reported as a limit to the ability to integrate adaptation planning into operations. This was, in fact, a source of tension for farmers, who reported that not knowing firms' plans for varieties and volumes for the next years' crops narrowed their window for planning investments into new equipment and rotational crops to maintain soil health.

"We don't know what they [distillery] is going to do or need, so we can't plan or determine how much to invest in equipment and seeds."

– Farmer Scotland

The informal pathways or shadow spaces were paramount to maintaining flows of information critical to adaptive capacity. In both case studies, communications between the firms' representatives and individual farmers served to enhance production monitoring and minimise field-related losses. While some communications were ordinary business practices, some at the senior levels included anticipatory views of the firm's longer-term strategies, which could help associates prepare for reconfigurations or shifts in the business model. The formal communications were limited due to business secrecy, but personal communications arose from a sense of respect or personal connection between senior officials in different companies. In Scotland, for example, the head of the cooperative had worked closely with the distillery over three decades and the Director communicated with him on a semi-daily basis, despite institutional communications being limited. This provided the cooperative with feedback on the quality of the crops and valuable information that helped farmers to anticipate shifts in the firm's strategy and quality preferences.

The back channel provided an informal mechanism to mitigate conflict arising from changes in the formal relationships. These informal pathways provided avenues to introduce new information and complementary capabilities to individual firms, which could later be diffused among stakeholders. This could also include information from knowledge brokers, which are institutions or individuals that can codify and organise data for interpretation by senior planners to be integrated into planning cycles. When formal avenues of communication became insufficient to provide insight into the direction of business plans, the informal communications compensated and provided space for the assemblage to align its adaptive activities to the firm's strategic direction. The adaptive measures occurring at the boundaries between organisations provided space for participation by associates, the co-production of innovations, and the distribution of benefits from technology to minimise climate impacts.

The learning loops explained in the literature as learning processes aligned with the degrees of change within or driven by the business model. The single-loop learning adaptive actions provided quick feedbacks at operational scales that allowed the maintenance of economic functions through incremental changes. Interruptions in operations, communications or outputs were addressed through small adjustments, such as increased technical visits, impromptu investments into power sources or flood protection dikes. While the changes observed in the business model suggested minor corrections in processes or the sudden deployment of resources, these changes were perceived by external associates and stakeholders as normal operational routines of the firm.

In double-loop learning, the reconfiguration of relationships between different components of the firm, or between the firm and external actors, served to reframe operations, sourcing patterns or social values that might have maintained stability in the relationships in order to maintain economic functions. Internal changes may occur first in these situations, with changes to sourcing locations and potential consequences being considered for the following production cycles. Adjustments to the business model and relationships associated with double-loop learning were observed in Scotland after new technologies, such as heating or drying rooms in farm locations, were introduced, changing the relationships between farms and the cooperative, and the cooperative and the firm. The ability to maintain grain stores opened the possibility for change in pricing strategies and sale windows, increasing the potential gains in revenue and resources necessary for adaptation investments.

While these actions were observed in some farms, this form of learning has emerged primarily in response to increased impacts on crop production. Cooperation occurred among members of the assemblage in Scotland to achieve efficiency gains, including timeliness of delivery, accuracy and compliance with specific parameters established by the market and enforced by the firm. These actions were then based on economic calculations, but, in the case of interaction among local farmers and households, the actions were reframed by cultural norms or local social practices. This suggested the local assemblage considered some form of adaptation trajectories in its decision-making.

Triple-loop learning moves the firm and its associates towards more transformative processes. Desirable or forced transformation processes are negotiated along pathways. In some instances, these pathways had already shifted due to previous reconfigurations of the relationships. Alternatively, this occurred when the firm's connections to its stakeholders moved from the operational to strategic level, where the firm assessed their economic and strategic value instead of their operational performance.

The empirical data points to two instances where partnerships led to the creation of new organisations and business models. For example, in the case of the partnership between the agricultural company and technology firm (I3) described in Chapter IV. This case illustrated possible transformational processes deliberately undertaken as a result of more radical changes in the firm's functions and its relationships to external stakeholders, were a new organisation with entirely new characteristics emerged to be part the assemblage, one which integrated adaptation as its main purpose by delivering services to support adaptive processes.

The transformational changes observed indicated that the pursuit of alternatives to the collapse or interruption of their functions by firms and their associates may have been a last resort option guided by financial calculations and the desire to maintain the form of the assembly. More innovative changes required firms to undertake extensive internal changes or manage external transformations that recognised climate impacts as recurring. The historical and geographic characteristics and cultural legacy in these locations presented resistance to this degree of change. The two case studies revealed a relationship between farmers and firms that could temporarily provide resources to maintain the current economic assemblage, but the configuration showed signs of strain, suggesting that changes would be necessary to enhance adaptive capacities.

In Scotland, greater independence for both the farmers and distillers to connect directly to the global market enhanced their adaptive capacity. In contrast, in Mexico, greater connection and mutuality seemed the optimal strategy for enhancing farmers' future adaptive capacity. The difference was the availability of financial resources and subsidies. The policy options to support adaptation in locations with increasing degrees of climate risks requires that funding be complemented by support to build technical capacity. In Scotland, government-funded research institutions worked closely with farmers and offered them support. In Mexico, financial resources became available, but expertise and scientific knowledge were limited by the capacity to utilise new sources of information, technology and innovation for adaptation solutions.

The adaptive actions capable of contributing to adaptation capabilities integrated climate information, co-produced innovations and created additional resources by providing alternatives in a declining production system. The initial hypothesis of the thesis proposed that the deployment of resources through business model mechanisms that leverage a focal firm core capability would enhance the organisation's contributions to adaptive capacity.

However, empirical data indicates that current business models limit contributions by failing to integrate climate adaptation into business routines. The business models did not accommodate necessary changes for firms to participate in more social forms of adaptation. Rather, business model configurations amplified or compounded risks in communities exposed to climate and disaster risk. This is explained by a number of business model characteristics: restrictions on the flow of information, hierarchical priorities, compartmentalisation of knowledge and resources and changes driven by economic calculations to accommodate the firm's preferences.

The range of resources and capabilities available for firms to diversify operations across different geographic locations enabled them to create minimal adaptation capacities in the assemblage, and the organisation reconfigured its activities, and relationships to maintain business functions instead.

The confines of formal agreements limited the adaptation options available for associates, making them components of a business model that has yet to recognise adaptation needs, and while it's not the responsibility of the firm to account for adaptation, their practices are unwillingly creating barriers for the assemblage to make decisions critical for future adaptation.

Transformation of the social functions of the firm must transition towards codifiers and diffusers of information, enabling adaptation and recognising the imbedded nature of their operations, where climate change might require them to accept the trade-offs of short term gains, for long term sustainable forms of cooperation as climate change will present challenges in all geographic locations.

In viewing these organisations from the lens of climate change adaptation there is an opportunity to uncover the limits of capitalist driven business models and study their role in creating additional risks and constraints for adaptation. The conceptualisation of the business model, as informed by economic geography, recognises the firm embedded in local communities through their suppliers, employees, local governments, research associations and other groups. This highlights a place-based approach to understanding the interactions between natural variables and the human system to identify changes that shape local adaptive trajectories.

The empirical data substantiates that business mechanisms respond to climate and disaster risk by transferring risk to specific locations within their operational activities. In economic sectors or supply chains with equal levels performance, the accumulation of risk is managed through established risk management mechanisms and contractual agreements that distribute risk among the associates or suppliers of the firm. However, when there is uneven performance or capacity among diverse actors in a socio-economic assemblage, the firm's preferences prevailed. In vulnerable economic assemblages, exposure to climate and disaster impacts was amplified by profit-maximising behaviour expressed in the practices of the focal firm.

The experts deployed by the firm or cooperatives attenuated risk by providing alternative options for managing crop losses, such as pooling resources, coordinating pest management or deploying critical information to protect crops before natural hazards occur. The different actors, such as specialists or expert institutions act in the assemblage as modulators, effectively suppressing business responses that might reconfigure the model or alter routines to keep adaptive actions at incremental adjustments levels. The relationships along the supply chain are operationalised through connections where information is delivered with both factual and symbolic meanings that trigger different actors to behave in particular ways in response. The messages in the information create expectations in the supply chain, as they may present solutions to broadly-experienced impacts in the assemblage, such as the introduction of new varieties of crops.

The information that flowed from the firm towards members of the assemblage, including the cooperative and farmers, is filtered or codified according to business restrictions or interests, which potentially amplifies risk and limits the ability of assemblage members to develop accurate perceptions of future climatic impacts on their farming operations. For example, the firm not sharing its predicted harvest volumes for future years with the cooperative or farmers was reported to create uncertainty and limit their ability to request machinery loans and purchase necessary equipment for bigger farms. Similarly, where large corporations have acquired distilleries, communications that once were personal are now impersonal, requiring farmers to decode and attempt to predict firm behaviours from corporate values of efficiency and productivity.

Adaptation requires values, norms and practices to change in response to novel adaptation options, but, within these assemblages, the firms had failed to integrate adaptation, and the current business model configuration prevented necessary internal changes to develop critical adaptation capacities and foresight. Instead, when firms reached a threshold of what constituted acceptable losses from climate impacts, adaptation actions transferred the burden of making key adjustments to routines outwards to the members of the assemblage, in many instances only allowing incremental adjustments at the farm scale.

The co-production of local innovation and learning loops allowed the firms to integrate these resources and provided indications to the sources of knowledge and information that could contribute to adaptation capacities. In time, the firms might recognise these operational level practices to shape their business model, including new components that address conversion of innovation into adaptation resources, or institutional practices to combine knowledge systems in adaptation planning.

CHAPTER VII

Conclusions

The empirical evidence suggested that profit-maximising business models, individual firms demonstrated a preference for adaptation options that strengthened their adaptive capacity in the short run, however some exceptions were observed where adaptation resources were co-produced and integrated into daily activities at the boundary or periphery of the assembly. This created niches where adaptive capacities in the assemblages where strengthened, and where some of the individuals or sub-assemblages had new properties, meaning ability to expand their functions over different weather patterns due to improved uses of technology, or ability for foresight deriving from access to new information.

In those instances, the firms' expertise, local experiences and experimentation became complementary, rather than secondary, to economic calculations. The assemblage was better positioned to cope with climate-related impacts and extreme weather events associated to climate change.

While the managerial view of adaptation conceives supply chains as a series of linked economic actors where firms must build their own resilience, this approach is limited to the firm-centric conceptualisation, which is a narrow view of long-term adaptive options, subverted to the norms and influence of dominant economic business models.

A radical transformation, would require reconstructing the role of the private sector by developing models that account for the spatial and temporal dimensions undergoing climate stress, and one which allows the cycles and locations of the firm to more closely align with the needs of adaptation, that is with the reality of a changing planet, a changing society and a changing economy.

The thesis opens a research agenda for inquiry into the determinants of forced or deliberate transformative changes driven by climate change and economic decision making, and the role that information, resources, visions of adaptation and practices have in allowing egalitarian forms of adaptation change firms behaviour in communities undergoing climate stress.

The theoretical underpinnings of the work focus on the rationality of profit-maximising behaviour at a moment of change, when decisions presented to the firms can determining the course of adaptation. Particularly, beginning to identify when these thresholds become evident for economic agents in the private sector, can provide an entry point to change or reconfigure, and transform the underlying architecture of the private sector, one which emerges as an assemblage that is characterised by awareness of the existential threats the planet is facing.

Current development policy and studies have framed adaptation and private sector contributions to development in the same language as that of the private sector, a technocratic approach to leveraging their resources and skills for development, event championing corporate social responsibility as a form of contribution to social life. This mechanism still places the firm outside of the processes of environmental and social changes driven by climate change, as the firm seems to remain an observer that makes sporadic contribution, which must comply with the norms and value firms considers useful.

The solutions need to find their sources in science, in the various languages that social and natural inquiry provide, as well, as the notions of justice and inclusions which have been ardently been defended in the various political spaces over the past decades. The firms as economic actors and embodiment of capitalist market ideals have carried to our current realities, the aspirations of past centuries, which have become constraints and barriers to necessary changes in developmental pathways.

Therefore, the organisations currently operating under the private sector category, need to integrate a new language, one that has in the past been capable of providing new technologies and information to enhance economic functions, but now has the potential for triggering transformational changes for societies to find new purpose in economic life, and while the firms resistance might delay, arrest or divert these efforts to move into a more rational pathway, it has become evident that irrational economic growth and inequality are realities that require rapid radical transformation to respond to a changing climate.

The idea of incremental forms of adaptation refers to systems adjustments to continue functioning as the established order, by continually addressing developmental failures, in infrastructure, education, resources, and poverty. These become central to adaptation processes, but explaining capitalist behaviour to examine climate change adaptation, places purpose and agency in the same context as economic life, but climate change moves the critique outside of capitalism, where a broader view of civilization renders some of our organisations and practices irrational. Then, climate change tests our ideas about how we organize our social life in public and private spheres, the challenge for radical transformation is to redefine the binary category of private and public.

The concept of radical transformation for the private sector in the thesis was considered first at the organisational scale, where the private sector centric view is informed by technical changes, then shifts to consider transformation in more niched systems or assemblages, where economic trade-offs and blind spots, or adaptation traps are negotiated among the members. The idea of conceptualising economic assemblages, allows to view increasing pressures from climate change as disrupting operations in organisations, but also among a group of actors and resources, connected by different forms of economic activity. In this form, profit-maximising business models of any dominant economic actors become a mechanism used to assess technical responses to climate impacts, presenting adaptation options as cost-benefits, and creating unique challenges or forcing choices for different members of the assemblage, both as individuals and as a community.

If the scope for social forms of innovation is to be considered as forms of acceptable adaptation, firms need to recognise that adaptation is no longer a viable technical response (Hulme 2017), but a concept that can radically challenge the way society is organized. Thereby, co-production of new mechanisms and visions becomes fundamental to undertake the changes needed for adaptation pathways consistent with fair and equitable forms of social life. This thesis explored the technical responses of individual firms across different economic sectors to emerging impacts from shifts in weather patterns, and extreme climate events associated with climate change. The empirical data suggests that firms respond to these stressors, without noting climate change as a central driver, but continuing on a technical assessment of cost-value of their actions. In this regard, changing relationships or allowing economic activities to collapse, seems business as usual when these become unprofitable for the firm.

Empirical Contributions

What are the types of emerging climate adaptation actions amongst private sector firms?

The empirical data demonstrated how individual firms mobilised resources for adaptation, driven by the business model practices that have become routine. The cycles of operations, and incremental adjustments begun to contain damages from climate stressors but planning for adaptation remained a financial practice. The firms codified information and shared as necessary to maintain efficiency, but in many forms compartmentalised the information critical for developing foresight and long-term planning.

These practices in public adaptation space narrowed adaptation options when firms limited information or targeted investments to those locations or actors allowing them to maintain their performance, shaping private forms of adaptation regimes. These help firms develop adaptive capacity at the organisational rather than assemblage level. The classification of adaptation actions provided a nuanced view of their influence on longer-term adaptation trajectories and the connections to firms' business models, as drivers to actions influencing adaptation. The data described the elements that connected socio-economic assemblages undergoing climate and disaster impacts in a variety of sectors. The different actions of the for-profit organisations revel a pattern of practices based on corporate norms, that are considered acceptable forms of adaptation in the private sector, and which can inform predictions on future adaptive behaviour of firms under extreme forms of climate stress. The results suggest the limits to contributions to adaptation in the private sector are embedded in firms' business models.

These organisations have to gradually make sense of a complex set of social and environmental variables in different locations under recurring climate impacts, which must then be considered in conjunction with economic calculations. These unprecedented challenges require individual firms to recognise the limits of economic growth under climate change and operate with a longer-term planning horizon that accounts for shifting consumption patterns and possible cycles with limited gains.

In the firms studied, information and knowledge co-produced by members of the assemblage was the key in managing routine climate impacts but still insufficient to make sustained contributions to collaborative and broadly beneficial forms of adaptation. Within this boundary for the study, where business routines showed patterns of investment, extraction of value, flows of information and allocation of infrastructure the firms shifted operations to accommodate for changing climate patterns.

In the long run, firms will need to focus adaptation efforts on the following activities: maintaining connections between their business models and a recognisable assemblage, increasing local investments in adaptation, sharing critical information to develop strategic foresight and cooperation. Otherwise, they will risk the gradual collapse of the assemblage and strain communities facing extreme climate impacts.

Finding a balance between stability and change under climate change is proving difficult as firms remain tied to the principle of growth in their current operations, even though adaptation may require delaying or retreating for long-term sustainability of the assemblage. These actions might change the signals firms send to assemblages, as some of the firm's current decisions can be interpreted as maintaining functions at the expense of the local community. This balance can be found through business model innovations that deliberately plan, report and document adaptive actions to sustain operations, enhance local resilience and secure future operations.

As climate change impacts begin to affect more profit maximising organisations, this will force firms to rethink their business models and those that understand the different sources of innovation to develop the necessary adaptive capacities, not solely for the firm, but for a broader assemblage of social and economic actors, allowing to construct more suitable adaptation pathways. The technocratic implementation of 'sustainable development' is not sufficient, in fact, it has worked to support in some ways business models reinforcing maladaptive practices and highlighting the success stories in the private sector.

While more radical changes would provide solutions to leap forward to different functions of the private sector in social life, this also constitutes an argument that calls for a fundamental change in social order and purpose. There needs to be a reorientation on the aspirations and variants of business as usual, but the climate crisis, as Klein (2014) argues, this changes everything for some, for others remains a path to expand economic functions and establish models that sustain economic growth.

Theoretical Implications

- How can individual firms open or limit adaptation options for host communities?
- What are the sources of business model innovation in the context of adaptation?

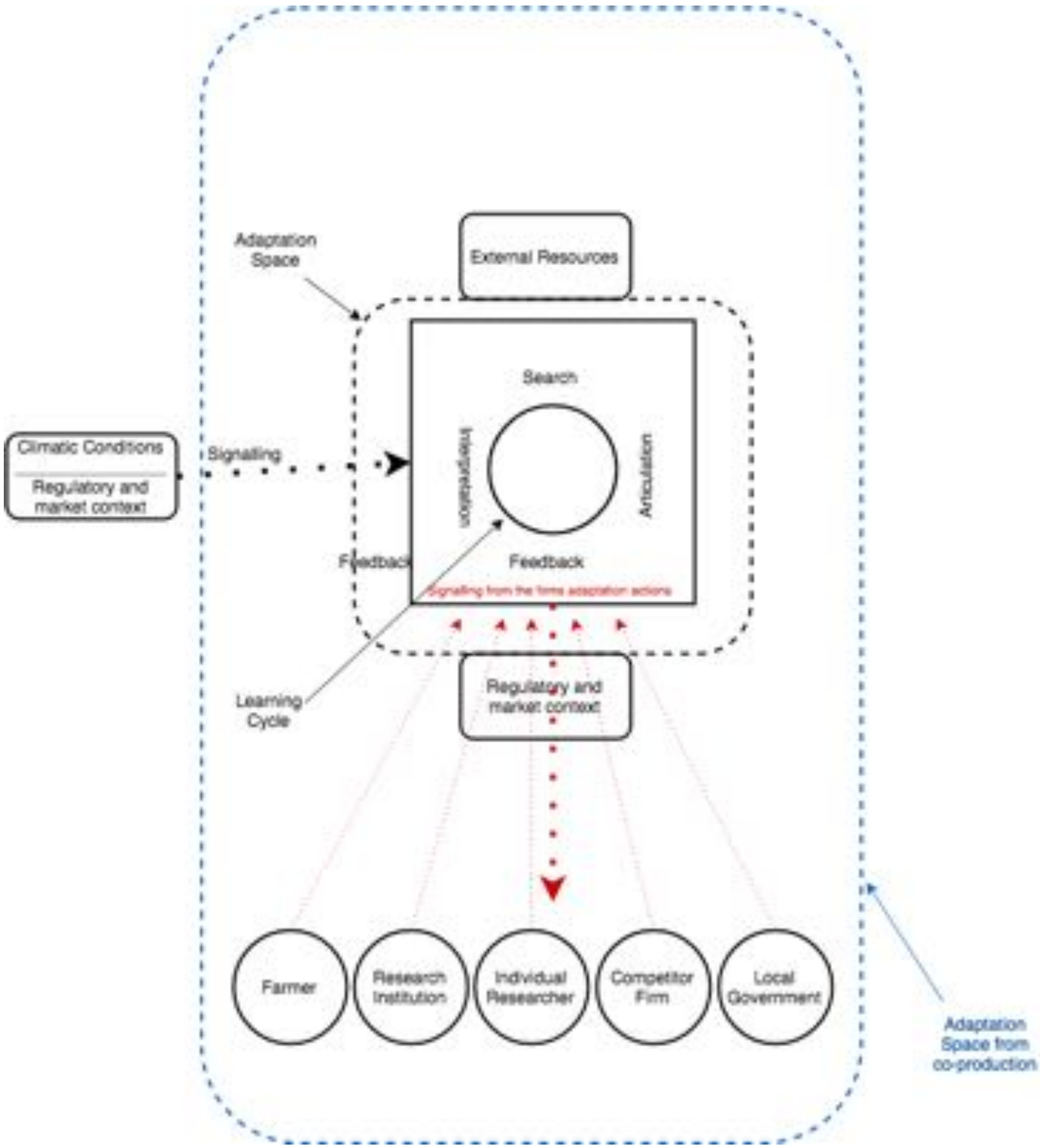
In order to achieve sustained forms of adaptation, models to analyse adaptation processes must evolve to examine economic behaviour in ways that focus on motivations and incentives enhancing or limiting adaptation processes. The underlying architecture of individual firms is connected to individual biophysical and social changes in local systems but recognising the locations and cycles in which interactions occur is critical to understanding adaptation options or preferences.

The contestation or alignment by individual members of assemblages in response to changes can also be framed in connection to dominant economic agents. There are emergent qualities of assemblages that begun to cope with climate related impacts that include co-produced knowledge and cooperation, and that can be used to model and explain future adaptation trajectories. These assemblages form according to lateral flows of information and resources, initially circumventing the barriers of the business models firm, but ultimately returning to configurations of the business according to profit maximisation.

A business model that widens the adaptation space in assemblages, would include signals that firm send from the actions in response to climate impacts, but also the new sources of signals, providing new information to inform the firms calculations on adaptation beyond the accepted business drivers. This business model innovation would align with more social views of adaptation, moving the firm towards a more egalitarian type of responses to climate stimuli.The figure 32 below illustrates in black colour the original organisational learning model proposed by Berkhout et al (2004), and in colour a revised model accounting for the new sources of information and knowledge, including external responses or exchanges coming from different points or actors in an assemblage. The learning cycle of the firm is then enhanced by the inputs from a variety of assemblage members, triggering changes in the business model.

The results or actions resulting from the final stage of the learning cycle, the interpretation of the firm of signals in response to perceived climate impacts, determine or shape what the firms accepts as viable or desired forms of adaptation responses, expressed in the individual adaptation actions, which in turn, send different signals or patterns of signals to the members of the assemblages influencing different learning cycles of individuals, organisations or the wider community.

Figure 31 Assemblage learning for Business Model Innovation and Climate Change Adaptation



These signals are not solely emerging from formal mechanisms or relationships, but also from a shadow or informal system of communications between the firm's decision makers and stakeholders or actors in the assemblage. In the case of farmers, these exchanges were based on trust, historical ties and common vision or goals. Similarly, local innovations co-created by the firm's field employees in operations and external actor's, such as individual farmers provided the inputs to widen the adaptation space. In the original model of Berkhout et al. (2004), the external resources are limited to material resources as sources of assets or finance for creating adaptation space, however, external information, complementary skills and local knowledge of individuals and organisations have the ability to widen the adaptation space for the firm and the assemblage itself.

Policy Implications

As a society, we risk widening inequalities by allowing firms and economic agents to self-select adaptation trajectories that affect entire regions under climate pressures. The flow of technical and financial resources can enable dominant economic agents, who function with dated business models that narrowly consider their social impacts, are able to pursue private regimes as forms of adaptation. This creates the conditions for forced economic transformations that preference certain higher-performing members of assemblages and serve to perpetuate the disparity between firm capabilities. An alternative theory of change for adaptation finance would need to account for the lower-performing assemblage of associates, households and individuals connected to individual firms.

The different financial investments and incentives provided by governments could reinforce current unsustainable adaptation practices, which are driven by inadequate business models. These resources might gradually erode adaptive capacity and even lead local systems to collapse under the increasing pressure of climate change. This maladaptive process could move lower-performing or vulnerable individuals or groups towards more precarious conditions, forcing them to seek alternative livelihoods to compensate for the losses experienced from climate impacts. The winners and losers' scenario would be in shaped not solely by increasing risk and losses from impacts associated to climate change, but from policy mechanism, practices and resources poorly allocated focused on firm adaptation, and trickle-down approaches to adaptation. In parallel, focal firms in the same economic assemblage could reinforce this configuration by overlooking lower-performers when providing increased resources and information that bolster adaptive capacities.

As the economic assemblage continues to work guided by the firms reassembling supply chains to key locations or actors, the potential to replicate the same ordering or assembly of performance based on the profit maximising model will likely result in the same incremental process of eroding capacities. Investment and innovations driven by local knowledge and co-production processes will avoid depleting capacities or resources from the different assemblage members in new locations undergoing climate impacts. A new theoretical framing of adaptation should challenge the wider economic architecture to account for the limits of focusing on economic performance. A more rational approach to investing in adaptation in the private sector would consider the long term social wellbeing of individuals, groups and communities under climate pressure. This is a choice that will be presented to individual firms at the thresholds of operational capacity.

In closed economic relationships, assemblage members were presented with a trade-off between maintaining minimal income security with declining or stagnant accumulation of resources or shifting their economic activities to different assemblies to secure resources in sectors with lower levels of climate risk with different degrees of uncertainty. This has important policy implications, as investments in climate adaptation and local development to enhance resilience in rural areas must account for the specific characteristics of the economic relationships of individuals or households within supply chains.

Changes in the focal firms' business models were driven by a combination of three different elements: first, the formal and informal linkages of individuals at operational levels cooperating to develop responses to climate stress; second, access to or development of complementary technical skills even for short periods, such as researchers or technology providers who introduced information at the operational level; and third, foresight based on economic calculations that also integrated social and environmental variables. Introducing new information, technologies or local innovations as adaptive measures have a moment of optimal opportunity for success, which is determined by the firm's business cycle. Sequencing of action is therefore important. Policy interventions, financial investments or knowledge brokers should intervene in multiple firms at the critical times when business cycles are naturally aligned.

Limits of the PhD

This research does not prove causality between firms' adaptive actions and adaptive capacities. Neither the method nor the approach was designed for this. The method sought to identify and unpack actions that contributed to adaptation as means-to-end chains, and to understand the spatial impacts of adaptation behaviour taken based on economic calculations. It was not possible to analyse the different relationships at the periphery of the firm's business model nor to account for the numerous entry points for information and resources into the assemblage. Further research is required to examine the boundaries of the assemblages and the individual members that stabilise, contest or resist dominant members of the assemblage.

While a stronger geographical approach was considered for the study, such as using quantitative methods to determine correlations between the income and resources of assemblage members in relation to their proximity to the firms' operations hubs, it was not possible to further examine these relationships between distance and distribution of resources, and connections to the business model due to limited time and resources.

New Research Frontiers

How assemblages change under climate stress? And what new properties emerge in new assemblages?

The pathway to business model innovation to further adaptation begins with local co-production and strengthened adaptive capacities for the firm and its associates. Each element can place the assemblage on a positive adaptation trajectory, in which the different vectors or connections between the firm and its associates enhance system wide adaptation. The evidence indicated that firms could also limit flows of information necessary for decision-making at the local level by mechanically following their established business models. Harmful practices like this can be overcome by reconceptualising the boundary or purpose of the assemblages to the benefit of individuals, households and the community in long-term adaptive processes.

Individual firms play an important role in sustaining social memory, learning and incentivising experimental knowledge in locations where climate impacts continue to put stress on individuals and livelihoods. Firms can also help to develop local capacity by providing complementary resources and knowledge and deliberately engaging in adaptation efforts at multiple levels. If anything, climate change is challenging the functions of firms by prompting them to recognise remote locations or actors as critical to adaptation. In these exchanges, historically-established relationships could be undone, but they could also be relied upon as critical stabilisers for the assemblages.

In the case studies, formal flows of information between key people in different firms circumvented the formalised economic relationships between the firms and the farmers, or other associates. The more formal structures of information-sharing in profit-maximising settings include proprietary information and strategic plans. These are at the core of value creation mechanisms, and secrecy is believed to be paramount to maintaining competitiveness, however, these practices are premised on accepted models gradually eroding adaptation space.

While firms planned years in advance or undertook adaptation studies and assessments to determine adaptation options, the information was compartmentalised or siloed in the firm. The potential market-related losses from perceived future loss of value determined the firms' decisions to limit information available to associates, narrowing the scope of foresight. This presented a challenge to business model innovations in which firms integrate adaptation planning that considers other actors. In the long run, there will be a limit on the ability of individual organisations to cope with continuous climate impacts if they do not recognise their interdependence with local stakeholders.

The future research agenda on adaptation should conceptualise economic configurations differently by examining adaptation outcomes based on relational forms of coordination. Some evidence was found of visual and digital information to represent business models and operations. This could become a tool for integrating and modelling the assemblage, as well as individual components within the firms. Understanding how to reshape business models to integrate an array of social and biophysical variables into decision-making can widen equitable adaptation processes.

Forced transformational processes resulting from individual acceptance of environmental and social burdens can increase the likelihood of assemblage collapse and local economic relationships being rearranged in undesirable ways. Transformative adaptation is already underway in areas under extreme weather and climate stress. Developing further understanding of firm behaviour and decisions in these locations could present future adaptation options and explore their potential impacts on local livelihoods.

The premise of the thesis was to explore the ways in which information and adaptation planning could change business models. However, the economic orientation of firms remained the unchangeable characteristic that drove adaptive actions. The next step is to identify the thresholds where firms might begin to align their operations to undertake radically different social functions, and incentives to assemble more social forms of adaptation responses. Acting in such a way would help these organisations to advance in just and rational ways as they cope with a future of uncertainty and continued change in the planet's climate.

A next step is to understand how the language of science might shape economic life, not as a form of disruptive innovations driven by firms to create new markets and practices, but as a combination of knowledge and practice, where the purpose is coproduced and negotiated among many, and where rationality becomes a central force of social life.

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Annex I: Sector Codes

UNFCCC PRIVATE SECTOR INITATIVE – CASE STUDIES on ADAPTATION ACTIONS DATABASE http://unfccc.int/adaptation/workstreams/nairobi_work_programme/items/6547.php			
Agriculture	1 : bunge	A1	1.
	2 : cafe_direct	A2	2.
	3 : cafedirect_plc_uk	A3	3.
	4 : chiles_nicaragua	A4	4.
	Green_farm2	A5	5.
	Greenfield_hydroponics	A6	6.
	5 : gsk	A7	7.
	6 : itc	A8	8.
	7 : jammu_and_kashmir_cooperative	A9	9.
	8 : john_deere	A10	10.
	Meinert enterprises	A11	11.
	9 : tartari	A12	12.
Chemicals	1 : basf	C1	13.

	2 : basf.wbcsd	C2	14.
	3 : Bayer	C3	15.
	4 : bayer_cropscience.wbcsd	C4	16.
	5 : ccp.wbcsd	C5	17.
Construction	1 : cemex	Co1	18.
	2 : dow.wbcsd	C02	19.
	3 : ecotelhado_ecoesgoto_final	Co3	20.
	4 : egis	Co4	21.
	5 : masdar	Co5	22.
	6 : mca	Co6	23.
	7 : royal_engineers	Co7	24.
	8 : urs_corporation	Co8	25.
Consulting	1 : ecofys	Cs1	26.
	Enterprise_works	Cs2	27.
	2 : freshfields_llp	Cs3	28.
	3 : global_climate_adaptation_partnership	Cs4	29.
	4 : maplecroft	Cs5	30.
	5 : mckinsey	Cs6	31.
	6 : riverside_technology	Cs7	32.
	7 : waycarbon	Cs8	33.
Energy	1 : anglian_water	E1	34.

	2 : ankur	E2	35.
	eeab	E3	36.
	3 : energias_brasil_revised	E4	37.
	4 : entergy	E5	38.
	5 : eskom	E6	39.
	6 : hi_nation_ab	E7	40.
	7 : himal_power	E8	41.
	8 : nova_oceanic	E9	42.
	Oia_ssn	E10	43.
	9 : sunlabob	E11	44.
	10 : veolia	E12	45.
Finance	Allianz	F1	46.
	1 : basf	F2	47.
	2 : basix	F3	48.
	3 : bolsa_florest	F4	49.
	4 : calvert_investments	F5	50.
	5 : cbre	F6	51.
	6 : fonkoze	F7	52.
	7 : hsbc	F8	53.
	8 : intact_financial_corporation	F9	54.
	9 : munich_re	F10	55.

	10 : rabobank	F11	56.
	11 : sompo	F12	57.
	12 : swiss_re	F13	58.
	13 : the_climate_corporation	F14	59.
	14 : the_travelers_companies	F15	60.
Food and Beverage	1 green_mountain_coffee	FB1	61.
	nestle	FB2	62.
	: pepsico	FB3	63.
	2 : pepsico_south_central_america	FB4	64.
	3 : scotch_whisky_association	FB5	65.
	4 : sekem	FB6	66.
	starbucks	FB7	67.
	5 : suntory	FB8	68.
	6 : the_coca_cola_company	FB9	69.
Information and Communication Technologies	1 : acclimatise	I1	70.
	2 : china_mobile_communications	I2	71.
	3 : cisco	I3	72.
	4 : clim_systems	I4	73.
	5 : ericsson	I5	74.
	6 : ge	I6	75.
	7 : ignita	I7	76.

	8 : intel	I8	77.
	9 : microsoft	I9	78.
	10 : tata	I10	79.
	11 : vivo_clima	I11	80.
Retail	1 : levi_strauss	R1	81.
	2 : unilever	R2	82.
	3 : unilever.wbcsd	R3	83.
Science	Ilhas_brasil	S1	84.
	femsa_foundation	S2	85.
	1 : mars_ibm	S3	86.
	2 : naturally_advanced_technologies	S4	87.
	3 : siemens	S5	88.
	4 : syngenta.wbcsd	S6	89.
Tourism	1 : apple_vacations_et_at	T1	90.
	2 : intrawest	To2	91.
	Rifugio_dorigoni	To3	92.
Transport	1 : copa_airlines	T1	93.
	2 : network_rail	T2	94.
	3 : obb	T3	95.
	4 : psi_database_rhdhv_aas	T4	96.
	5 : uic	T5	97.

Mining	15：anglo_american	M1	98.
	16：bhp_billiton	M2	99.
	17：rio_tinto	M3	100.

Annex II: Adaptive Actions by Sector

Agriculture, fisheries and forestry sector Type of Adaptive Actions identified					
Strategic	Cooperative	Mixed CCM/CCA	Technological	Cooperative	Prescriptive
Strategic					
Implement and strengthen climate change resilient local agriculture crops					
Adding shade trees for farms at 1200 mts.					
Reforestation projects undertaken					
Reforestation of grasslands higher up at 3200 mts.					
Analyse and identify risks, opportunities and adaptation actions for CC					
Initiatives in five major areas: Wasteland development, soil and moisture conservation, value added crop rotation and animal husbandry programs					
Strategy to reduce disproportionate dependence of rural households on land for supporting livelihoods					
Economic empowerment of women and community development					
Study to demonstrate viability and profitability of new crop which can be grown in semi-barren rained farmlands					
Identified high value, high resilient and pest free crop as alternative					
Constant cross breeding of seeds					
Climate change adaptation strategy developed and implemented to assist farmers (1. Management of pest and disease, 2. Food security, 3 Family planning, 4 Nature conservation)					
Food security by focusing on efforts to increase food production though better farming methods, using organic and inorganic fertilizers					
Strategic adaptation plan created					
Cooperative motivates farmers to switch to low risk, high value aromatic and medicinal crops that thrive in unpredictable climate as a strategy for CCA					
Develop products and services more suitable for small scale farmers					
Provision of advisory services coordinated with technology sales					
R&D for boat building to manufacture boats suited for volatile weather conditions					
On-going continuous education and capacity building programs, workshops					

Create guarantee fund with national micro finance companies
Fund radio program at local radio stations on climate change addressing major local risks
Sensitization and training on wetland conservation, river banks and natural forests
Plant fruit trees to supplement income
Emphasise awareness and training of local actors on climate change risks
R&D to examine agricultural productivity and adaptation issues

Operational
Monitor and study changed in crops and soil, while maintaining a seed bank of varieties more resistant to CC.
Training on better practice services
Improving farming practices
Monitor appearance of plant diseases
Transport security provided by pick up service
Certification of organic controlled agriculture
Visits by technical team of the company to farmers
Conserve forest areas to avoid future degradation
Strengthen capacity building
Technical advisory expert deployments
Advisory services
Agroforestry practices
Management of pest and disease. Focusing on early planting, use of resistant varieties of crops, early detection and control and research on new disease
Procurement of crop varieties that withstand common pest and disease
Selection of locations for crop seeding and growing
Supervising that plots and ridges are well constructed
Data collected in a correct manner
Support local decision making
Implementing basic and easy plantation management practices
Monitor the recurrence of human disease emerging from changing climate conditions
Contain disease vectors at local level
Sharing knowledge through agro practices
Mixed
Linking adaptation to the voluntary carbon market
A percentage of firm income goes to a new association, a unique example of using mitigation (capturing carbon) to fund adaptation
Technological
Energy saving technologies at farm level, protection of swap and wetlands.

Provide suppliers with water efficient irrigation systems
Plastic mulch technology implementation to control and preserve moisture levels in soil
Use drip irrigation
Leverage digital technology and customised farm extension services to empower farmers and raise rural income
Cooperative
Tools and sharing experiences with other companies in the area
Invest in shaded areas for shared used among farmers
Prescriptive
Family planning, programs for farmers using radio programs and training. Family planning campaigns
Participated in regional project for corporate adaptation to climate change to improve the regional policy on “Entrepreneur Strategy for climate adaptation in Central America”.

Consulting Type of Adaptive Actions identified					
Strategic	Operational	Technological			
Strategic					
Research into climate risks and adaptation measures					
Development and market launch of innovative and future focused products					
Restoring surrounding ecosystem in critical infrastructure location rather than building storm water management					
Construct wetland ecosystem to replace infrastructure.					
Supplying customers with stress-tolerant plants, which in turn helps improve local yields of food crops like corn, soy and wheat that are exposed to extreme weather conditions.					
Varieties that help plants adapt to short term abiotic stress, such as drought, salinity, heat or cold; and - nitrogen use-efficient varieties that will help mitigate one of the most potent GHGs: nitrous oxide (N2O)					
Operational					
Supplying crop protection agents					
Technological					
Equip plants with special ability to tolerate stressful situations					

Innovative and environment-friendly solution to provide effective and stable coastal protection. Through a specially developed elastomer polyurethane system (Elastocoast), dikes are protected by absorbing the force of the breaking waves and slowing down the water masses.
Super absorbers are being piloted for a reforestation project in the Brazilian rain forest. These super absorber polymers have an enormous water absorption capacity and can effectively store it in soil, thereby increasing water storage capacity.
Drought tolerant crop, first biotechnology-derived drought-tolerant crop in the world.
Stress Shield products

Construction sector Type of Adaptive Actions identified					
Strategic	Operational	Experimental	Policy		
Strategic					
Incorporation of adaptation principles into road design and construction projects adding value to clients					
Coordinate the selection of 60 individual reconstruction projects after Hurricane Rita based on sustainability criteria					
Incorporate retrofits to protect against future flood and storm damage					
Projecting terraces and stairways have been designed to control solar irradiation during summer, while the garden and rooftop greenery reduce the heat island effect and contribute to passive cooling					
Carried out collaborative study to investigate the impact of climate change on highway policy and standards to identify adaptation opportunities					
Risk and probability assessment of the effects of climate change on the highway network, and the development of recommended adaptation actions for key policy areas.					
Climate change adaptation action plan was developed					
Alignment will make maintenance, repair and inspection activities more efficient and consistent across the region. This will lead to capital and whole-life resource savings, and an increasing synergy of operations across the region.					
Rainwater collection system, alongside use of low-consumption fittings, has been designed to lower potable water requirements.					

Provision of building materials aimed at adapting infrastructure to climate change in response to an increased market demand for these solutions
Developed a wide-ranging business on the back of climate change-related services including designing flood defences and re-engineering gas pipelines
Offer public and private clients services that incorporate the consideration of climate change adaptation.
Operational
Reusing wastewater on industrial site
Experimental
Research project for a low cost and low impact residential complex
Propose a new paradigm for a decentralized wastewater and organic waste that could be integrated to the building landscape as green roof and green wall, increasing the green infrastructure in urban areas
Policy
Develop policy report

Consultancy sector Type of Adaptive Actions identified					
Strategic	Cooperative	Technological			
Strategic					
Build adaptive capacity within a professional member organisation					
Dialogue on the topic of CC and its relevance for the legal sector					
Corporate investment in climate change as donations for supporting adaptation projects					
Undertake studies on economics of adaptation					
Collaboration with lead international organizations					
Partnerships with local consulting firms					
Establish and develop water use associations					
Corporate investment in climate change as donations for supporting adaptation projects					

Briefing notes for broader legal community
Operational
Raise awareness
Focused briefings to senior managers
Training
Technological
Communications Technology for dissemination of expert science

Energy Sector Type of Adaptive Actions identified					
Strategic	Cooperative	Mixed	Technological	Cooperative	Prescriptive
Strategic					
Incorporation of climate change consideration into 5-year water resource management planning cycles					
Research into climate change impacts and solutions					
Embedding CC considerations into business processes and 'hard' adaptation measures					
Commissioning of a report to look at potential economic risks of climate change in key operational areas					
Flood protection for critical water assets, source duplication, network enhancement and customer focused water efficiency programme (saved domestic customers 3 mega litres a day)					
Risk assessments (2005 and 2010) and use of results into business planning processes					
Detailed cost benefit analysis for individual actions included in current business plan (2010-2015)					
Analysis of historical data and identification of relevant meteorological variables					
Improving resilience of infrastructure and staff by incorporating adaptation issues into long term planning and risk strategies					

Completed scoping exercise to develop adaptation strategy focused on risk related to water availability for power generation, extreme weather events impacting ability to supply and infrastructure damage, and relocation of people
Looking at correlation of each risk with company assets or operations to identify candidate threats for response and adaptation
Integration of adaptation into a six-point plan on climate change to ensure reliability and continuity of energy supply
Putting together a business continuity group specifically to look at broader implication of climate in the context of other serious businesses threats
Scoping study to identify likely changes in several key climatic and related physical effects over the near term (20 years), medium (20-50) and long term (end of the 21^{st} century)
Relocation of important business centres, including moving data and transmission centre.
Creation of redundancy in data storage through service areas
Technological
Use of dry-cooling technology in new power stations which reduces water consumption by 90% (with efficiency losses)
Platform able to anticipate climate variations that can potentially affect power grids, supporting pro-active solutions and avoiding and minimizing the interruption of the energy transmission and distribution
Hired consultants to use GIS to map potential changes in climate and physical effects to the company's service area and other areas where it has large scale investments
Modelling impacts and development of robust strategies to reduce overall cost of adaptation and minimize operational disruptions
Development of a tool in deployment in Smart Grids in Brazil, inserting the new concept of grid: enables the convergence of space-time and information about climate and environmental variables, providing the "3D" vision for the smart grid
Prescriptive
Encouraging suppliers to improve water conservation, quality monitoring and waste water treatment and recycling practices

Finance sector Type of Adaptive Actions identified					
Strategic	Cooperative	Mixed	Technological	Cooperative	Prescriptive
Strategic					
Flood catastrophe bond to spread risk of severe floods across a global fund, thereby spreading risk across clients as a form of climate adaptation					
Investments to assist remote communities to build climate resilience by: acquiring radio centrals, installing artisan water capture systems and power generators for food storage in seasons with prolonged droughts and floods					
Organise participatory workshops with community to discuss better climate solutions					
Company support to adaptation projects in Madagascar because it provides a unique way to engage staff across Europe, Middle East and Africa in an initiative that is extremely relevant to this sector					
Launch Micro Insurance Catastrophic Risk Organization – donor capitalized insurance facility specializing in protecting poor from disaster risks					
Disaster insurance to approximately 55,000 microloan clients					
Education program on individual risk reduction and disaster risk awareness					
Entry into the crop insurance market in partnership with insurance company					
Identify areas for further key research					
Incentives for risks management aligned well with insurance premiums for mal-adaptations not to occur					
Partner with World Bank funded initiatives to address frequency and severity of natural disasters and impacts in developing countries					
Development of climate change risk reduction program					
Conduct assessments to identify disaster risks and vulnerable community groups, including household surveys					
Provide market mechanisms that enable adaptation measures in developing countries					
Engage community identified projects to reduce risk and build climate resilience					

Establishment of a climate change research facilitation programme with the UK Met office to allow fund managers to asses climate risks and impacts in their portfolios
Development of a detailed understanding of physical risk of climate change to help bank maximise opportunities, such as marketing new products and focus on best ways to respond to risk
Investments to spur innovation in sustainable yield enhancing pesticides and soil moisture monitoring for farmers
Actions to widen the use of private sector risk financing methods for adaptation to climate change as business strategy
Operational
Established an online forum for gathering insurance related expertise applied to climate change impact issues
Qualitative and quantitative research of rural markets and farmers carried out
Encourage companies to develop forward thinking climate strategies
Reassess exposure to risk because of climate change, pricing strategies and policy terms and conditions
Update catastrophe modelling
Act as reinsurer for climate change adaptation projects
Reassess coastal underwriting practices
Offer risk control services and redesigning insurance travel prices by considering disaster risk
Provide financial support and technical expertise
Provide information and price incentives for insured parties to mitigate personal and commercial losses due to extreme weather events
Technological
Weather monitoring stations installed to measure rainfall levels that aided in improving the company's image in front of farmers
Cooperative

Release of a climate vulnerability Assessment with maps risks for the G20 in 2020 from climate impacts in terms of food losses, water stress and rising healthcare costs to advice both the bank and clients, and shape future products
Dissemination of findings with target group of 35 thought leaders to identify 2 or 3 critical adaptation issues in their area of expertise
Work with local organizations to design microcredit and microfinance products to increase capability of communities to cope with disaster risks and impacts
[redacted]
Promote insurance related approached in cooperation with other organisations and initiatives, and within existing frameworks such as the UN, IFI's. International donors and private sector
Participate in the launch of the global insurance industry statement on adaptation to climate change in developing countries at the UNFCCC COP meeting in Cancun 2010
Encourage policy makers to make sound policy decisions that encourage resilience-building and preparation for CC both in the US and abroad
Partner with government bureau to develop tools for municipal governments to better evaluate vulnerabilities to climate change and prioritize investments in modernisation of municipal infrastructure
Fund innovative research project to identify appropriate initiatives and action plans for government, business and civil society to better adapt to cc
Launch program for public educations and awareness raising campaigns to teach low income households about disaster risk and options for insurance schemes
Engaging community and government outreach
Information
Generate and disseminate high quality climate data on climate trends and impacts
Experimental
Conduct and support pilot projects for the application of insurance related solutions in partnerships, and through existing organisations and programs
Launch pilot project using weather index insurance as an effective tool in developing countries
Prescriptive

Ask companies to manage risk from physical impacts of climate change (coffee brands)

Food and Beverage Sector Type of Adaptive Actions identified					
Strategic	Cooperative	Mixed	Technological	Cooperative	Prescriptive
Strategic					
Creation of an agricultural development centre					
Adapt practices, strategies and infrastructure					
Include forest conservation among the companies' environmental projects					
Development of a stewardship strategy					
Incorporate adaptation priorities into a compressive sustainability strategy					
Devise set of indicators related to adaptation priorities to track progress of climate strategies					
Promote crop diversification and create localized supply base for the company					
Invest in projects that promote maintenance of biodiversity crops and discovery of new species more adaptable to the effects of climate change					
Scoping study to assess the risk of climate change to the sector and identify initial adaptation options					
Operational					
Direct seeding					
Introduction of less water intensive plantations for farmers					
Set up fruit processing plants close to community farmers					
Integrate climate risks and opportunities into each business unit and key decision making processes					
Technical support for conscious use of natural resources, development of better working conditions and improved productivity					
Involved in water conservation efforts in business operations, including use of rainwater harvesting initiatives in manufacturing locations (roof water harvesting and recharge ponds)					

Optimisation of water use
Development of new methods of communication and consultation with local stakeholders
Forest preservation to generate more groundwater than the among used by its processing plants and expand natural water sanctuaries
Watershed conservation and community natural resource management projects
Cooperative
Collectively as a sector undertake adaptation actions to tackle impacts of climate change
Act on the opportunity for the whole sector to move forward collectively to understand and act on climate change risks
Share information and experience to generate ideas to build adaptive capacity at industry sector levels
Information
Raise awareness of specific business risks and build capacity within the industry to enable individual companies to adapt and include climate change into business registers
Raising awareness among producers on the impacts of climate change
Industry workshops to raise awareness of climate change impacts and adaptation
Run awareness programs on water and forest conservation

Information and Communication Technologies sector Type of Adaptive Actions identified					
Strategic	Technological	Experimental	Transformational		
Strategic					
Develop information-based applications which help the company advance mitigation and adaptation priorities					
Technological					
Climate change Software training to key staff and initiation of case study applications					

Explore the use of mobile technologies to deliver weather information to rural communities
Online climate risk screening tool designed to identify and understand risk from climate change to companies and investments
Implement a pluviometric data collection network to increase in the warning and monitoring system of extreme weather events
Send pluviometric data in real time to platforms
Implementation of pluviometres (rain gauge equipment) in telecomm sites located in risk areas across the country
Experimental
Research initiative to reduce emissions from deforestation with co-benefits for adaptation and conservation of forest ecosystems
Build working prototypes of resource and risks management decision support tools
Engage in pilot projects to work with local business and municipalities
Transformational
Transformed partnership into independent non-profit organisation

Annex III: NVIVO Sample of Tables

Agriculture, forestry and fisheries

	A : Action	B : Products and Services for Adaptation
1 : bunge	22	0
2 : cafe_direct	5	0
3 : cafedirect_plc_uk	7	0
4 : chiles_nicaragua	23	0
5 : gsk	0	0
6 : itc	4	1
7 : jammu_and_kashmir_cooperative	2	0
8 : john_deere	0	1
9 : tartari	0	1

Chemicals

	A : Action	B : Products and Services for Adaptation
1 : basf	0	3
2 : basf.wbcsd	0	2
3 : Bayer	4	1
4 : bayer_cropscience.wbcsd	0	2
5 : ccp.wbcsd	2	0

Construction

	A : Action	B : Products and Servic...
1 : cemex	0	1
2 : dow.wbcsd	1	0
3 : ecotelhado_ecoesgoto...	0	1
4 : egis	1	1
5 : masdar	0	2
6 : mca	0	3
7 : royal_engineers	1	1
8 : urs_corporation	4	0

Consultancy

	A : Action	B : Products and Services for Adaptation
1 : ecofys	6	0
2 : freshfields_llp	2	0
3 : global_climate_adaptation_partnership	0	3
4 : maplecroft	0	2
5 : mckinsey	2	1
6 : riverside_technology	3	1
7 : waycarbon	0	2

Energy

	A : Action	B : Products and Services for Adaptation
1 : anglian_water	6	0
2 : ankur	0	2
3 : energias_brasil_revised	1	1
4 : entergy	6	0
5 : eskom	6	0
6 : hi_nation_ab	0	2
7 : himal_power	0	0
8 : nova_oceanic	0	1
9 : sunlabob	1	0
10 : veolia	0	2

Finance

	A : Action	B : Products and Services for Adaptation
1 : basf	0	3
2 : basix	2	6
3 : bolsa_forest	2	0
4 : calvert_investments	4	1
5 : cbre	3	0
6 : fonkoze	2	2
7 : hsbc	4	1
8 : intact_financial_corporation	3	2
9 : munich_re	6	0
10 : rabobank	4	0
11 : sompo	3	2
12 : swiss_re	2	0
13 : the_climate_corporation	0	2
14 : the_travelers_companies	7	1

Food and beverage

	A : Action	B : Products and Service...
1 : pepsico	4	0
2 : pepsico_south_central_america	5	0
3 : scotch_whisky_association	5	0
4 : sekem	5	0
5 : suntory	3	0
6 : the_coca_cola_company	3	0

Information and technology

	A : Action	B : Products and Services for Adaptation
1 : acclimatise	0	2
2 : china_mobile_communications	1	2
3 : cisco	6	1
4 : clim_systems	1	2
5 : ericsson	2	0
6 : ge	1	1
7 : ignita	0	2
8 : intel	0	2
9 : microsoft	0	0
10 : tata	0	1
11 : vivo_clima	4	0

Retail, tourism, transport and mining

	A : Action	B : Products and Services for Adaptation
1 : levi_strauss	1	0
2 : unilever	0	1
3 : unilever.wbcsd	4	0
4 : mars_ibm	2	0
5 : naturally_advanced_technologies	0	1
6 : siemens	0	1
7 : syngenta.wbcsd	0	7
8 : apple_vacations_et_al	2	1
9 : intrawest	6	0
10 : copa_airlines	10	0
11 : network_rail	2	0
12 : obb	0	1
13 : psi_database_rhdhv_aas	5	0
14 : uic	2	2
15 : anglo_american	2	0
16 : bhp_billiton	1	0
17 : rio_tinto	5	0

	A : Magnitude 1	B : Magnitude 2	C : Magnitude 3	D : Stakeholder
1 : bunge	5	15	2	7
2 : cafe_direct	0	2	3	3
3 : cafedirect_plc_uk	1	6	4	8
4 : chiles_nicaragua	7	13	4	9
5 : gsk	0	0	0	0
6 : itc	1	1	2	1
7 : jammu_and_kashmir_cooperative	0	1	1	2
8 : john_deere	0	0	0	0
9 : tartari	0	0	0	0

	A : Magnitude 1	B : Magnitude 2	C : Magnitude 3	D : Stakeholder
1 : basf	1	2	0	0
2 : basf.wbcsd	2	0	0	0
3 : Bayer	3	1	0	0
4 : bayer_cropscience	2	0	0	0
5 : ccp.wbcsd	0	0	2	0

	A : Magnitude 1	B : Magnitude 2	C : Magnitude 3	D : Stakeholder
1 : cemex	0	0	0	0
2 : dow.wbcsd	1	0	0	0
3 : ecotelhado_ecoesgoto_final	0	0	0	0
4 : egis	0	1	0	0
5 : masdar	1	1	0	1
6 : mca	0	2	0	0
7 : royal_engineers	0	1	0	0
8 : urs_corporation	0	2	1	1

	A : Magnitude 1	B : Magnitude 2	C : Magnitude 3	D : Stakeholder
1 : ecofys	0	6	0	0
2 : freshfields_llp	0	1	0	1
3 : global_climate_adaptation_partnership	1	2	0	0
4 : maplecroft	0	1	0	0
5 : mckinsey	0	2	0	1
6 : riverside_technology	0	4	0	5
7 : waycarbon	1	1	0	0

	A : Magnitude 1	B : Magnitude 2	C : Magnitude 3	D : Stakeholder
1 : anglian_water	7	1	0	0
2 : ankur	0	0	0	0
3 : energias_brasil_revised	1	0	0	0
4 : entergy	5	1	0	0
5 : eskom	2	4	0	0
6 : hi_nation_ab	0	0	0	0
7 : himal_power	0	0	1	0
8 : nova_oceanic	0	1	0	0
9 : sunlabob	0	0	1	3
10 : veolia	0	0	0	0

	A : Magnitude 1	B : Magnitude 2	C : Magnitude 3	D : Stakeholder
1 : anglian_water	7	1	0	0
2 : ankur	0	0	0	0
3 : energ[illegible]evised	1	0	0	0
4 : entergy	5	1	0	0
5 : eskom	2	4	0	0
6 : hi_nation_ab	0	0	0	0
7 : himal_power	0	0	1	0
8 : nova_oceanic	0	1	0	0
9 : sunlabob	0	0	1	3
10 : veolia	0	0	0	0

	A : Magnitude 1	B : Magnitude 2	C : Magnitude 3	D : Stakeholder
1 : basf	1	2	0	0
2 : basix	2	0	1	3
3 : bolsa_florest	1	0	5	0
4 : calvert_investments	1	3	0	0
5 : cbre	1	0	2	3
6 : fonkoze	0	2	1	1
7 : hsbc	2	2	0	0
8 : intact_financial_corporation	0	3	0	0
9 : munich_re	0	6	1	0
10 : rabobank	0	1	3	3
11 : sompo	0	2	0	1
12 : swiss_re	0	2	0	5
13 : the_climate_corporation	0	0	0	0
14 : the_travelers_companies	3	4	0	1

	A : Magnitude 1	B : Magnitude 2	C : Magnitude 3	D : Stake...
1 : pepsico	2	2	0	1
2 : pepsico_south_central_america	0	3	1	2
3 : scotch_whisky_association	0	5	0	1
4 : sekem	3	2	0	3
5 : suntory	1	2	0	1
6 : the_coca_cola_company	1	1	1	2

	A : Magnitude 1	B : Magnitude 2	C : Magnitude 3	D : Stakeholder
1 : pepsico	2	2	0	1
2 : pepsico_south_central_america	0	3	1	2
3 : scotch_whisky_association	0	5	0	1
4 : sekem	3	2	0	3
5 : suntory	1	2	0	1
6 : the_coca_cola_company	1	1	1	2

	A : Magnitude 1	B : Magnitude 2	C : Magnitude 3	D : Stakeholder
1 : acclimatise	0	1	0	0
2 : china_mobile_communications	1	1	0	0
3 : cisco	0	5	1	2
4 : clim_systems	1	2	0	0
5 : ericsson	0	2	0	0
6 : ge	0	1	0	0
7 : ignita	0	1	0	0
8 : intel	0	1	0	1
9 : microsoft	0	1	0	0
10 : tata	0	0	0	1
11 : vivo_clima	0	0	3	1

	A : Magnitude 1	B : Magnitude 2	C : Magnitude 3	D : Stakeholder
1 : levi_strauss	1	0	0	1
2 : unilever	0	0	0	1
3 : unilever.wbcsd	1	2	1	0
4 : mars_ibm	0	0	0	0
5 : naturally_advanced_technologies	0	1	0	0
6 : siemens	0	0	0	1
7 : syngenta.wbcsd	0	1	0	0
8 : apple_vacations_et_at	2	0	0	0
9 : intrawest	5	3	0	0
10 : copa_airlines	0	4	6	10
11 : network_rail	2	0	0	0
12 : obb	0	1	0	0
13 : psi_database_rhdhv_aas	0	6	5	1
14 : uic	0	2	0	1
15 : anglo_american	1	0	1	0
16 : bhp_billiton	0	1	0	1
17 : rio_tinto	4	0	0	0

	A : Business Model Element	B : Core Business Capability	C : Corporate Social Responsability	D : Partnership
1 : acclimatise	0	0	0	0
2 : allianz	0	0	0	3
3 : anglian_water	0	1	0	0
4 : anglo_american	0	1	0	1
5 : ankur	0	0	0	0
6 : apple_vacations_et_at	0	0	0	0
7 : basf	0	0	0	1
8 : basf.wbcsd	0	0	0	1
9 : basix	3	0	0	1
10 : Bayer	0	1	0	0
11 : bayer_cropscience.wbcsd	0	0	0	0
12 : bhp_billiton	0	0	0	1
13 : bolsa_florest	0	0	0	1
14 : bunge	0	0	1	0
15 : cafe_direct	0	0	0	1
16 : cafedirect_plc_uk	0	0	0	0
17 : calvert_investments	0	0	0	1
18 : cbre	0	1	1	1
19 : ccp.wbcsd	0	1	0	1
20 : cemex	0	0	0	0
21 : chiles_nicaragua	0	0	1	0
22 : china_mobile_communications	0	1	0	0
23 : cisco	0	0	0	2
24 : clim_systems	0	0	0	1
25 : copa_airlines	0	0	0	1
26 : dow.wbcsd	0	0	0	2
27 : ecofys	0	0	0	0
28 : ecotelhado_ecoesgoto_final	0	0	0	0

	A : Business Model Element	B : Core Business Capability	C : Corporate Social Responsability	D : Partnership
29 : seab	0	0	0	1
30 : egis	0	0	0	0
31 : energias_brasil_revised	0	0	0	1
32 : entergy	0	0	0	0
33 : enterprise_works	0	0	0	0
34 : ericsson	0	0	0	2
35 : eskom	0	0	0	0
36 : femsa_foundation	0	0	0	1
37 : fonkoze	0	0	0	0
38 : freshfields_llp	0	0	0	1
39 : ge	0	0	0	0
40 : global_climate_adaptation_partnership	0	0	0	0
41 : green_farm2	0	0	0	1
42 : green_mountain_coffee_roasters	0	0	0	2
43 : greenfield_hydroponics	0	0	0	0
44 : gsk	0	0	0	0
45 : hi_nation_ab	0	0	0	0
46 : himal_power	0	0	1	0
47 : hsbc	0	0	0	0
48 : ignita	2	0	0	0
49 : ilhas_brasil	0	0	0	1
50 : intact_financial_corporation	0	0	0	0
51 : intel	0	0	0	0
52 : intrawest	0	0	0	0
53 : itc	1	0	0	1
54 : jammu_and_kashmir_cooperative	1	0	0	1
55 : john_deere	0	0	0	1
56 : levi_strauss	0	0	0	0
57 : maplecroft	0	0	0	0
58 : mars_ibm	0	0	0	1
59 : masdar	0	0	0	0
60 : moa	0	0	0	0
61 : mckinsey	0	0	0	0
62 : meinert_enterprises	0	0	0	0
63 : microsoft	0	0	0	1
64 : munich_re	0	0	0	2
65 : naturally_advanced_technologies	0	0	0	1
66 : nestle	0	1	0	0
67 : network_rail	0	0	0	0
68 : nova_oceanic	0	0	0	1
69 : obb	0	0	0	0
70 : oia_ssn	0	0	0	0
71 : pepsico	0	0	0	2
72 : pepsico_south_central_america	0	0	0	0
73 : psi_database_rhdhv_aas	0	0	0	0
74 : rabobank	0	0	1	1
75 : rifugio_dorigoni	0	1	0	0
76 : rio_tinto	0	0	0	0
77 : riverside_technology	1	1	0	1
78 : royal_engineers	1	1	0	0
79 : scotch_whisky_association	0	0	0	0
80 : sekem	2	1	0	1
81 : siemens	1	0	0	0
82 : sompo	0	0	0	0
83 : starbucks	0	0	0	2
84 : sunlabob	1	0	0	0

85 : suntory	1	1	0	0
86 : swiss_re	1	0	0	1
87 : syngenta.wbcsd	0	0	0	0
88 : tartari	0	0	0	0
89 : tata	0	0	0	0
90 : thames_water	0	2	0	0
91 : the_climate_corporation	0	0	0	0
92 : the_coca_cola_company	0	0	0	1
93 : the_travelers_companies	1	0	0	0
94 : uic	0	0	0	0
95 : unilever	0	0	0	0
96 : unilever.wbcsd	0	0	0	0
97 : urs_corporation	0	0	0	0
98 : veolia	0	0	0	0
99 : vivo_clima	0	0	0	1
100 : waycarbon	0	0	0	0

Annex IV. List of Interviewees

Interviews California, USA, Baja California, Mexico	
1	Chief Executive officer
2	International Officer
3	Chief of Operations
4	Coordinator Central Zone
5	Coordinator South Zone
6	Coordinator Northern Zone
7	Research and Development Officer
8	Director of Operations BCN
9	Firm Agronomist
10	Field Coordinator Organic Certification Officer
11	Human Resources Officer
12	Financial Direction
13	Sales Director
14	Direction of International Operations
15	Coordinator of International Operations
16	Growing Operations Manager – National

17	Hydroponic Project Expert
18	Greenhouse Grow Manager
19	Open field Manager
20	Open field Manager
21	Research Water Resources
22	Farmer 1
23	Farmer 2
24	Farmer 3
25	Farmer 4
26	Farmer 5
27	Farmer 6
28	Farmer 7
29	Farmer 8
30	Farmer 9
31	Farmer 10
32	Farmer 11
33	Farmer 12
34	Farmer 13
35	Farmer 14

Interviews Scotland	
1	SWRI Scotch Whisky Research Institute Officer
2	SWA Scotch Whisky Association Officer
3	Climate Adaptation Scotland Officer
4	Cooperative CEO _ Highland Grain
5	Cooperative CEO _
6	Farmer 1
7	Farmer 2
8	Farmer 3
9	Farmer 4
10	Farmer 5
11	Farmer 6
12	Farmer 7
13	Farmer 8
14	Farmer 9
15	Coop Production Officer
16	Coop Sales Officer
17	Coop Finance Officer
18	Coop Logistics

19	Distillery Director
20	Distillery Sustainability Officer
21	Maltster Officer
22	Maltster Officer
23	Rural Training Centre
24	Grain and Seeds Officer

Annex V. Email to Research Participant

Sunday, April 22, 2018 at 7:10:14 PM Eastern Daylight Time

Subject: Attn. Mr. Simon Barry
Date: Friday, September 25, 2015 at 12:17:16 PM Eastern Daylight Time
From: Di Bella, Jose
To: info@highlandgrain.co.uk

Dear Mr. Barry,

I am a PhD student at the Department of Geography in Kings College London.

Gavin Dick from AHDB Cereals & Oilseeds gave your contact details.

My work is focused on climate change impacts and business, I am particularly interested in supply chains of companies that are linked to farmers.I am now actively inviting farmers, cooperative and distillery to be part of my research.

Gavin mentioned you would be the person to talk to in Scotland, as the Cooperative is a key link between farmers and distilleries.Over the past year I have been working with farmers in California, US where I helped a cooperative for farmers and companies they supply map and characterize business responses to identify future opportunities and challenges for cooperative, companies and farmers. The result is a report for the participants that can help visualize possible ways to plan for future impacts to their business model.

I am visiting Scotland with the sole purpose of meeting key people in the Elgin area, I would like to meet with you and explain a bit about my work. My intention is to invite the cooperative to be a key informant for the study.

Please let me know if you might be interested in a having a short conversation.

Kind regards,
Jose

Jose Di Bella
PhD Candidate – Expert Consultant
Climate Change Adaptation
Politics, Environment and Development Group

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King's College London
The Strand
London WC2R 2LS
UK
tel: +44 (0)207 848 2462

Page 1 of 1

Subject: Re: Your PhD
Date: Friday, September 25, 2015 at 3:52:05 PM Eastern Daylight Time
From: Di Bella, Jose
To: Simon Barry

Dear Mr. Barry,

Thank you very much for your prompt reply.

I will call you early next week to coordinate our meeting.

Kind regards,
Jose

From: Simon Barry <simon@highlandgrain.co.uk>
Date: Friday, September 25, 2015 at 1:44 PM
To: "jose.dibella@kcl.ac.uk" <jose.dibella@kcl.ac.uk>
Subject: Your PhD

Dear Mr Di Bella
I would be happy to meet with you. Perhaps you could give me a call next week to arrange a date/time.

Thanks,
Simon Barry

--
Simon Barry – Chief Executive
Highland Grain Limited

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Annex VI Photographic Memory

Scotland Monitoring Farm Meetings

Distillery Warehouses

California, USA and Baja California, Mexico

Destroyed Infrastructure farms in Baja California Sur, Mexico

Greenhouse, California

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